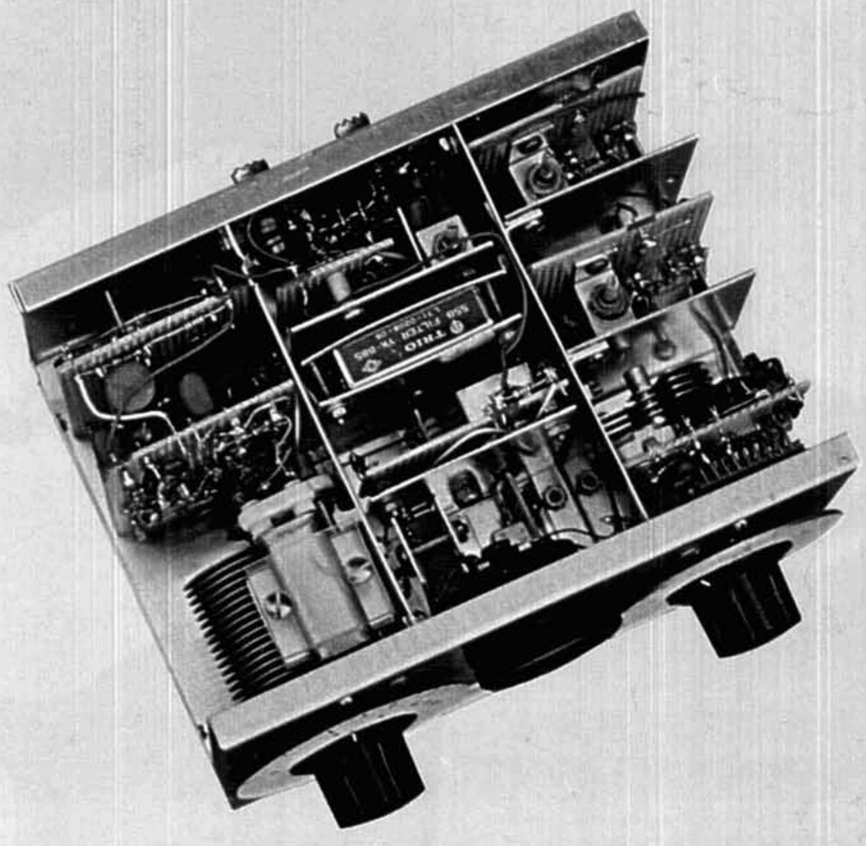
FEBRUARY 1984 / $2.50

ham radio • February 1984

ham radio magazine

- HF receiver performance
- better-sounding SSB
- meteor-scatter communications
- designing elliptic lowpass filters
- EMI/RFI shielding: new techniques (part 2)

THE QUIET FREQUENCY SYNTHESIZER:
USING VXO HARMONIC SELECTION

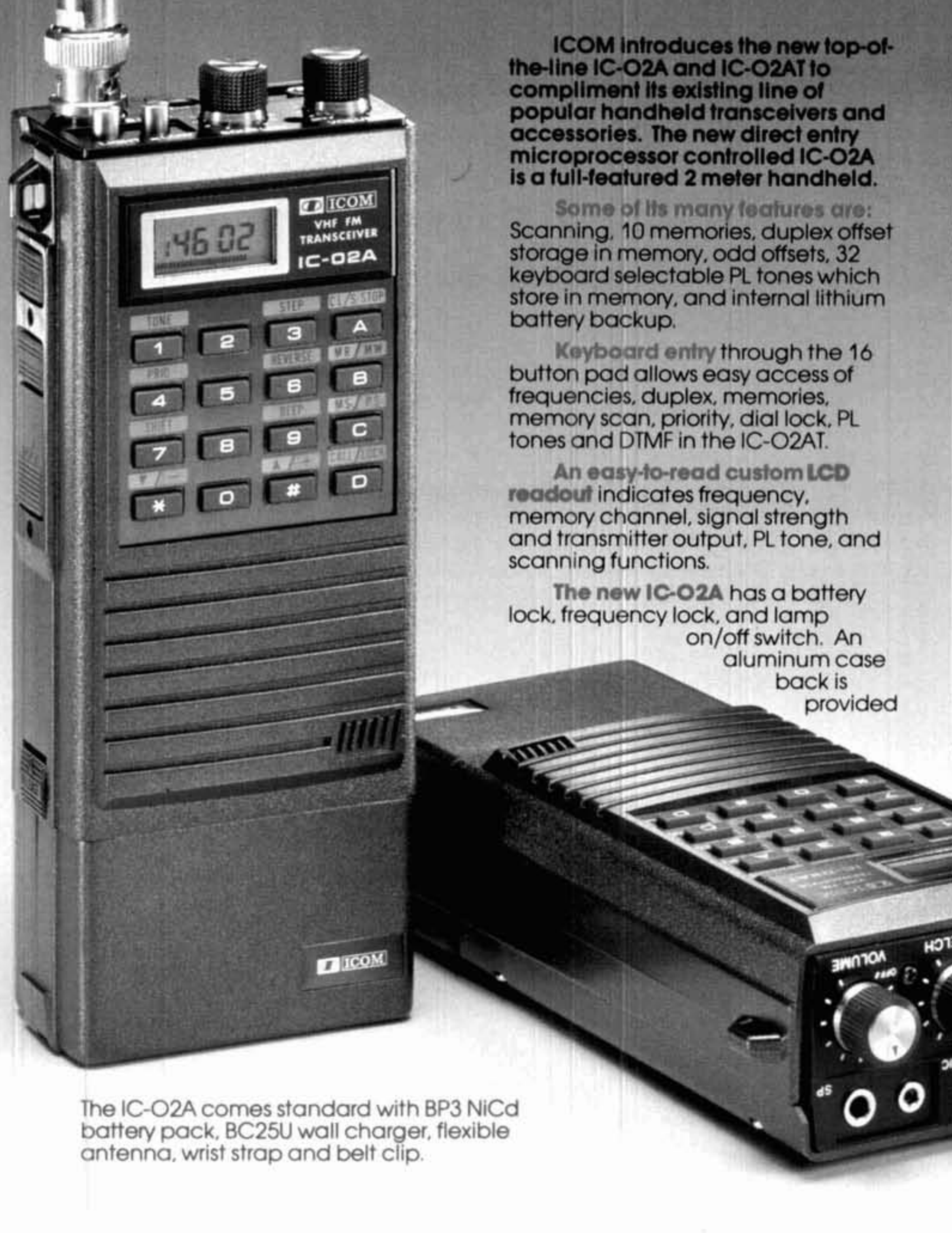


hr

focus
on
communications
technology

ICOM's IC-02A

Digital Readout, Scanning, Memories and...



ICOM introduces the new top-of-the-line IC-O2A and IC-O2AT to compliment its existing line of popular handheld transceivers and accessories. The new direct entry microprocessor controlled IC-O2A is a full-featured 2 meter handheld.

Some of its many features are: Scanning, 10 memories, duplex offset storage in memory, odd offsets, 32 keyboard selectable PL tones which store in memory, and internal lithium battery backup.

Keyboard entry through the 16 button pad allows easy access of frequencies, duplex, memories, memory scan, priority, dial lock, PL tones and DTMF in the IC-O2AT.

An easy-to-read custom LCD readout indicates frequency, memory channel, signal strength and transmitter output, PL tone, and scanning functions.

The new IC-O2A has a battery lock, frequency lock, and lamp on/off switch. An aluminum case back is provided for superior heat sinking when the IC-O2A is run at the standard 3 watt level or 5 watts (optional battery pack).

A variety of batteries will be available for the IC-02A including new long-life 8.4 volt and 13.2 volt packs. Charging may be done from a top panel connector for 13.8 volts which will also power transceiver operation.

ICOM's IC-2A(T) continues to be available...and its complete line of accessories work with the new IC-O2A.

✓ 150

The IC-O2A comes standard with BP3 NiCd battery pack, BC25U wall charger, flexible antenna, wrist strap and belt clip.

ICOM

The World System

ICOM America, Inc., 2112-116th Ave NE, Bellevue, WA 98004 **(206)454-8155** / 3331 Towerwood Drive, Suite 307, Dallas, TX 75234 **(214)620-2780**

Cards and plaque courtesy W6TC

EIMAC's new DX champion! The 3CX800A7.

Varian EIMAC continues to commit its development of reliable tubes for HAM radio.

The new, rugged 3CX800A7 power triode provides 2 kW PEP input for voice service or 1 kW cw rating up to 30 MHz. Two tubes will meet the new, higher power ratings authorized by the FCC.

Designed for today's low profile, compact linear amplifiers, the 3CX800A7 powerhouse is only 2½ inches (6.35 cm) high. Cooling requirements are modest and a matching socket, air chimney and anode clamp are available.

A data sheet and more information is available from Varian EIMAC. Or the nearest Electron Device Group sales office. Call or write today.

Varian EIMAC
301 Industrial Way
San Carlos, California 94270
Telephone: 415•592-1221

varian

✓ 188

ham radio

magazine

FEBRUARY 1984

volume 17, number 2

ham radio magazine is published monthly by
Communications Technology, Inc
Greenville, New Hampshire 03048-0498
Telephone: 603-878-1441

subscription rates

United States:
one year, $19.50; two years, $32.50; three years, $42.50

Canada and other countries (via surface mail):
one year, $21.50; two years, $40.00; three years, $57.00
Europe, Japan, Africa (via Air Forwarding Service):
one year, $28.00
All subscription orders payable in U.S.
funds, via international postal money order
or check drawn on U.S. bank

international subscription agents
are listed on page 102

Microfilm copies are available from
University Microfilms, International
Ann Arbor, Michigan 48106
Order publication number 3076

Cassette tapes of selected articles
from *ham radio* are available to the
blind and physically handicapped
from Recorded Periodicals
919 Walnut Street, 8th Floor
Philadelphia, Pennsylvania 19107

Second-class postage paid
at Greenville, New Hampshire 03048-0498
and at additional mailing offices
ISSN 0148-5989

Postmaster send form 3579 to *ham radio*
Greenville, New Hampshire 03048-0498

contents

cover: W3MT

REFLECTIONS

I enjoy operating because it's relaxing (sometimes), informative ("Roger, you're 5 and 9 — NEXT!"), and a good way to meet interesting people (that's true). It gives me an opportunity to try out new antenna designs, test my understanding of propagation, and, in general, stay more or less informed about what's happening. However, in the process I've noticed a trend worth examining — particularly by those who are part of it. I call it:

INSTANT PUDDING

Recently I've found myself reduced to mumbling into my beard about such-and-such practice by this-or-that individual. It appears that technically, at least, Amateur Radio has come of age, with instant power-on, QSY, tune-up, and antenna matching. We have the latest fully-synthesized, all-mode transceivers, full break-in amplifiers, and motor driven crank-up towers. With even half an effort we can work DXCC in a couple of weeks (or even on a weekend, during a contest). But in the process, something's been left behind. Call it courtesy, experience, operating skill, or just plain consideration for our fellow hams. Let me give you a few examples of what I'm talking about.

WD22XYZ calls CQ, is answered by a DX station, completes the contact, and stands by for any other DX calls on his frequency. Without a moment's hesitation, KD11PQC jumps in with kilowatts a-glowing and calls the DX station. When I was a novitiate to the hobby I learned fast that this is simply not done; unless WD22XYZ relinquishes the frequency, it's still his.

Another pet peeve of mine, heard more times than I care to recall, occurs when a DX station calls a directional CQ: "CQ, CQ, CQ, listening for W1's only!" The ensuing cacophony of calls includes all areas, states, and cities (with only slight exaggeration on my part). Of course, the DX station can control the situation if he continues to request the particular call area and refuses to give in by answering that loud W12 — *maybe*.

Signal quality reporting is another troublesome area. God help the operator who informs another that his signal leaves a little bit to be desired; for example, 20 kHz wide on glorious SSB. I made the mistake of telling another ham the other day that he was transmitting on two different frequencies simultaneously. His immediate reaction was, "That's impossible! It's probably your receiver that's overloading." I hastened to add that *both* of his signals were quite "clean"; it's just that he had two VFO's going at the same time. In all fairness to him, it turned out to have been the other operator in the QSO who was at fault. Fellas — I think most criticism is meant to be constructive. (Anyhow, whatever happened to pride in one's signal/station?)

How many times have you heard, "Roger, roger, roger, you're 5-9 plus. But will you please repeat your call and name and my report?" Please note that Q5 means "perfect copy" and S9, by IARU convention, is 50 microvolts RMS (in a 50 ohm system). By the way, it might be very useful to everyone if you knew what your Brand X receiver S9 was equivalent to. It might make the signal reports a little more meaningful when testing antennas or evaluating the performance of one's station over another's.

Full-power tune-up into the antenna seems to be occurring more and more often these days, usually when you're trying to pull that weak one out. If you *must* tune up on frequency (I won't mention dummy loads), listen first, wait, listen again to make sure that it's a clear frequency and *then* give a short request to see whether the frequency is in use. If it isn't, go ahead. Propagation being what it is, it's quite possible to believe that a frequency's clear when it's really quite occupied. If you have to apply full power to your antenna, load up when the band is truly dead: high noon on 160 meters, 4 A.M. on 10 meters. (I know — 160 and 10 meter operators will insist the bands are *never* dead.)

Communicasting is the term I use to identify operation by an individual who wants others to think he's communicating, even though he's really only broadcasting his highly opinionated, usually insulting, narrow-minded point of view. This practice has reared its ugly head more and more often on the lower bands recently — all in the name of exercising the right to free speech. With all due respect to rights, isn't use of the frequency spectrum — a precious, limited resource — a *privilege*? (If you have something to say, and you want other Amateurs to hear it, write a letter to *ham radio.* If space permits, we'll print it.)

To paraphrase a recent television ad describing the reasons for a stock brokerage's success, courteous operation is just "good old-fashioned work." In our case, if we were to stop expecting instant pudding — i.e., immediate gratification — and instead were more willing to hang in there, learn by example, develop expertise and the kind of operating skills that can only be acquired over a period of time, I, for one, would be a lot happier.

Rich Rosen, K2RR
editor-in-chief

MFJ RTTY / ASCII / AMTOR / CW COMPUTER INTERFACES

RTTY/ACSII/AMTOR/CW INTERFACE CARTRIDGE FOR VIC-20/C-64

NEW

MFJ-1228
$69.95

Most versatile RTTY/ ASCII/AMTOR/CW interface cartridge available for VIC-20 and Commodore 64. Gives you more features, more performance, more value for your money than any other interface cartridge available.

Same interface cartridge works for both VIC-20 and Commodore 64. Plugs into user's port.

Choose from wide variety of RTTY/ASCII/CW, even AMTOR software. You are not married to one on-board software package. Use MFJ, Kantronics, AEA plus most other software cartridge, tape or disk.

850 Hz and 170 Hz shifts on receive **and** transmit.

Has mark and space outputs for scope tuning.

Normal/Reverse switch eliminates retuning.

True dual channel mark and space active filters and automatic threshold correction gives good copy when one tone is obliterated by QRM or selective fading.

Easy, positive tuning with twin LED indicators.

Narrow 800 Hz active CW filter. Automatic PTT.

Exar 2206 sine generator for AFSK output.

Shielded XCVR AFSK/PTT interface cable provided. Plus or minus CW keyed output. FSK out.

Powered by computer (few mA.), no power adapter to buy or extra wire to dangle or pick up/radiate RFI.

Glass epoxy PCB. Aluminum enclosure. 4½x4½x1".

MFJ INTERFACE plus MFJ SOFTWARE CARTRIDGE

for VIC-20 or Commodore 64. MFJ-1228 PLUS MFJ-1250 or MFJ-1251 for one low price

$99.95
Save $20.00

SOFTWARE CARTRIDGE FOR VIC-20/C-64

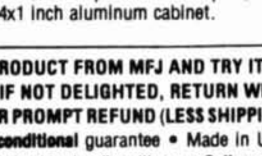
MFJ-1250/MFJ-1251
$49.95

Powerful MFJ software cartridge for VIC-20 (MFJ-1250, $49.95) and Commodore 64 (MFJ-1251, $49.95). Plugs into expansion port. Developed by MFJ.

Features RTTY/ASCII/CW send and receive, split screen display, type ahead buffer, message ports, status display, automatic CW speed tracking, parallel and VIC serial printer compatibility plus much more.

SUPER RTTY FILTER

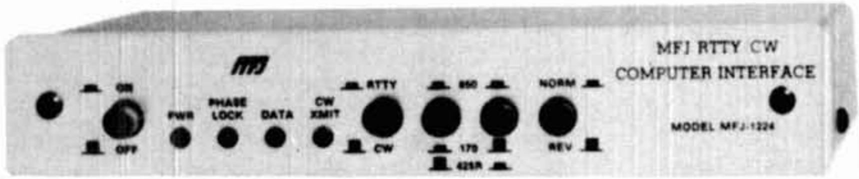
MFJ-725
$39.95
NEW



Super RTTY filter greatly improves copy under crowded, fading and weak signal conditions. Improves **any** RTTY receiving system. 8 pole bandpass active filter for 170 Hz shift (2125/2295 Hz mark/space). 200 or 400 Hz bandwidths. Automatic noise limiter. Audio in, speaker out jacks. On/off/bypass switch. "ON" LED. 12 VDC or 110 VAC with optional AC adapter, MFJ-1312, $9.95. 3x4x1 inch aluminum cabinet.

GENERAL PURPOSE RTTY/ASCII/ AMTOR/CW COMPUTER INTERFACE

Lets you send and receive computerized RTTY/ASCII/AMTOR/CW. Copies all shifts and all speeds. Copies on both mark and space. Sharp 8 pole active filter for 170 Hz shift and CW. Plugs between your rig and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 or most other personal computers. Uses MFJ, Kantronics software and most other RTTY/CW software.



MFJ Software plus MFJ Interface for VIC-20/C-64

Software cartridge alone, $49.95. Order MFJ-1250 for VIC-20, MFJ-1251 for Commodore 64. Includes cable to interface MFJ-1224 to VIC-20 or C-64.

$129.95

MFJ-1224
$99.95

New MFJ-1224 RTTY/ASCII/AMTOR/CW Computer Interface lets you use your personal computer as a computerized full featured RTTY/ASCII/AMTOR/CW station for sending and receiving. Plugs between rig and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 and most others.

Use MFJ (see MFJ-1250/1251 below) software for VIC-20, Commodore 64 and Kantronics for Apple, TRS-80C, Atari, TI-99 and most other software for RTTY/ASCII/AMTOR/CW.

Easy, positive tuning with twin LED indicators.

Copy any shift (170,425,850 Hz and all other shifts) and any speed (5-100 WPM RTTY/CW and up to 300 baud ASCII).

Copies on both mark and space, not mark only or space only, to improve copy under adverse conditions.

Sharp 8 pole 170 Hz shift/CW active filter gives good copy under crowded, fading and weak signal conditions. Automatic noise limiter suppress static crashes for better copy.

Normal/Reverse switch eliminates retuning. +250 VDC loop output drives RTTY machine. Speaker jack.

Automatic tracking copies drifting signal.

Exar 2206 sine generator gives phase continuous AFSK tones. Standard 2125 Hz mark and 2295/2975 Hz space. Microphone line: AFSK out, AFSK ground, PTT out and PTT ground.

FSK keying output. Plus and minus CW keying. CW transmit LED. External CW key jack.

Kantronics compatible socket.

Exclusive general purpose socket allows interfacing to nearly any personal computer with most appropriate software. Available TTL lines: RTTY demod out, CW demod out. CW-ID input, +5 VDC, ground. All signal lines are buffered and can be inverted using an internal DIP switch.

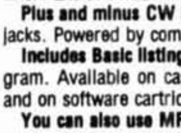
Use Galfo software with Apple, RAK with VIC-20, Clay Abrams with TRS-80C, N4EU with TRS-80 III, IV. Some computers with some software may require some external components.

Metal cabinet. Brushed alum. front. 8x1¼x6 in. 12-15 VDC or 110 VAC with adapter, MFJ-1312, !9.95.

MFJ-1223, $29.95, RS-232 adapter for MFJ-1224.

CW INTERFACE CARTRIDGE FOR VIC-20/C-64

NEW



MFJ-1226
$39.95

High performance CW Interface cartridge. Gives excellent performance under weak, crowded, noisy conditions. Works for both VIC-20 and Commodore 64. Plugs into user's port.

4 pole 100 Hz bandwidth active filter. 800 Hz center frequency. 3 pole active lowpass post detection filter. Exclusive automatic tracking comparator.

Plus and minus CW keying. Audio in, speaker out jacks. Powered by computer.

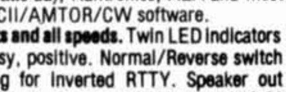
Includes Basic listing of CW transmit/receive program. Available on cassette tape, MFJ-1253, $4.95 and on software cartridge, MFJ-1254, $19.95.

You can also use MFJ-1250 (VIC-20) or MFJ-1251 (C-64), $49.95 each, RTTY/ASCII/CW software cartridge. Or use Kantronics, AEA and others.

Also copy RTTY with single tone detection.

UNIVERSAL SWL RECEIVE ONLY COMPUTER INTERFACE FOR RTTY/ASCII/AMTOR/CW

MFJ-1225
$69.95



MFJ-1225 plus MFJ-1250 or MFJ-1251 $99.95.

Use your personal computer and communications receiver to receive commercial, military and amateur RTTY/ASCII/AMTOR/CW traffic.

Plugs between receiver and VIC-20, Apple, TRS-80C, Atari, TI-99, Commodore 64 and most other personal computers. Requires appropriate software.

Use MFJ (see this ad), Kantronics, AEA and most other RTTY/ASCII/AMTOR/CW software.

Copies all shifts and all speeds. Twin LED indicators makes tuning easy, positive. Normal/Reverse switch eliminates tuning for inverted RTTY. Speaker out jack. Includes cable to interface MFJ-1224 to VIC-20 or Commodore 64. 4½x1¼x4¼ inches. 12-15 VDC or 110 VAC with optional adapter, MFJ-1312, $9.95.

ORDER ANY PRODUCT FROM MFJ AND TRY IT-NO OBLIGATION. IF NOT DELIGHTED, RETURN WITHIN 30 DAYS FOR PROMPT REFUND (LESS SHIPPING).
• One year **unconditional** guarantee • Made in USA.
• Add $4.00 each shipping/handling • **Call or write for free catalog, over 100 products.**

MFJ
MFJ ENTERPRISES, INC.
Box 494, Mississippi State, MS 39762

TO ORDER OR FOR YOUR NEAREST DEALER, CALL TOLL-FREE 800-647-1800. Call 601-323-5869 in Mississippi and outside continental U.S.A. Telex 53-4590.

presstop de W9JUV

THE "NO-CODE" LICENSE PROPOSAL WAS SOUNDLY DEFEATED, with not one commissioner voting for it at the December 14 FCC meeting. Presenting the item was Private Radio Bureau Chief Bob Foosaner, who pointed out that while a principal argument for No-Code was the supposed lack of growth in Amateur Radio, the service had grown from 300,000 licensees in 1975 to over 400,000. Furthermore, he continued, the nearly 5,000 comments filed ran 20:1 against No-Code, with even the handicapped it was supposed to benefit opposing it.

Commissioner Mimi Dawson, Studying For An Amateur License Herself, then asked what alternative entry to the radio spectrum might be available for "computer hobbyist" radio communications since Amateur opposition to No-Code did not make Amateur Radio attractive to that group. Foosaner responded, "The hobby class (license) may be something that replaces the CB type of thing...we'll find a spectrum available for this type of service."

Commissioner Comments During The Discussion Were All Complimentary to Amateur Radio, with Chairman Fowler in particular citing the service's many contributions. However, some observers feel the failure of No-Code and the resulting lack of growth in Amateur VHF or UHF band usage will greatly increase outside pressure on those bands. Not only is there the possibility of a non-Amateur "hobby class" competitor for spectrum, but various user groups are actively promoting 216-225 MHz as a land mobile band, plus use of 420-430 MHz.

W5LFL'S STS-9 2-METER OPERATION WAS AN UNQUALIFIED SUCCESS, from every point of view. He operated enough orbits to give the U.S. and the rest of the world at least several chances to hear and—hopefully—"work" him. His "CQ North America" was easily copyable. a thousand miles from Columbia's groundtrack, depending on spacecraft orientation.

Media Coverage Of The Event Was Outstanding, emphasizing the idea that now "the guy next door" could actually talk to an astronaut in space. Owen's chat with King Hussein, JY1, was highlighted, of course, but many average Amateurs across the country found themselves hosting TV news crews and chatting with talk show hosts or newspaper reporters.

Though Owen's Operating Method Disappointed Many who'd hoped to hear their calls come back from space, it made real PR sense. His acknowledging a few calls, then describing what he saw and what was going on in Columbia was far more interesting to non-Amateur listeners and media than long lists of calls. He also reported it almost impossible to copy many calls because of his single-earpiece headset. Though it appears most of those Owen was acknowledging were well-equipped VHF buffs with big signals, Owen's first review of his logging tape after Columbia's return did turn up some mobiles! Discipline was generally fair to good in most areas, though with some confusion and harassment.

Strong, Positive Effects On Amateur Radio are already being felt. Reinforcing the excellent exposure Amateur Radio got during the Grenada invasion, interest in becoming an Amateur seems to be at an all-time high. Inquiries about Amateur training courses are way up, and school-age Amateurs report many classmates asking about their hobby. NASA was also very pleased, with future operation by other licensed astronauts almost certain!

About 300 Callsigns Were Pulled Off The Logging Tape in Owen's initial runthrough. He feels quite a few more can come from a more painstaking review. Of the 300, about 75% were U.S., with no Japanese, Russians or Africans noted. Special QSLs for those who made it on the tape will be available shortly. Send QSLs and SWL reports to ARRL, with an SASE.

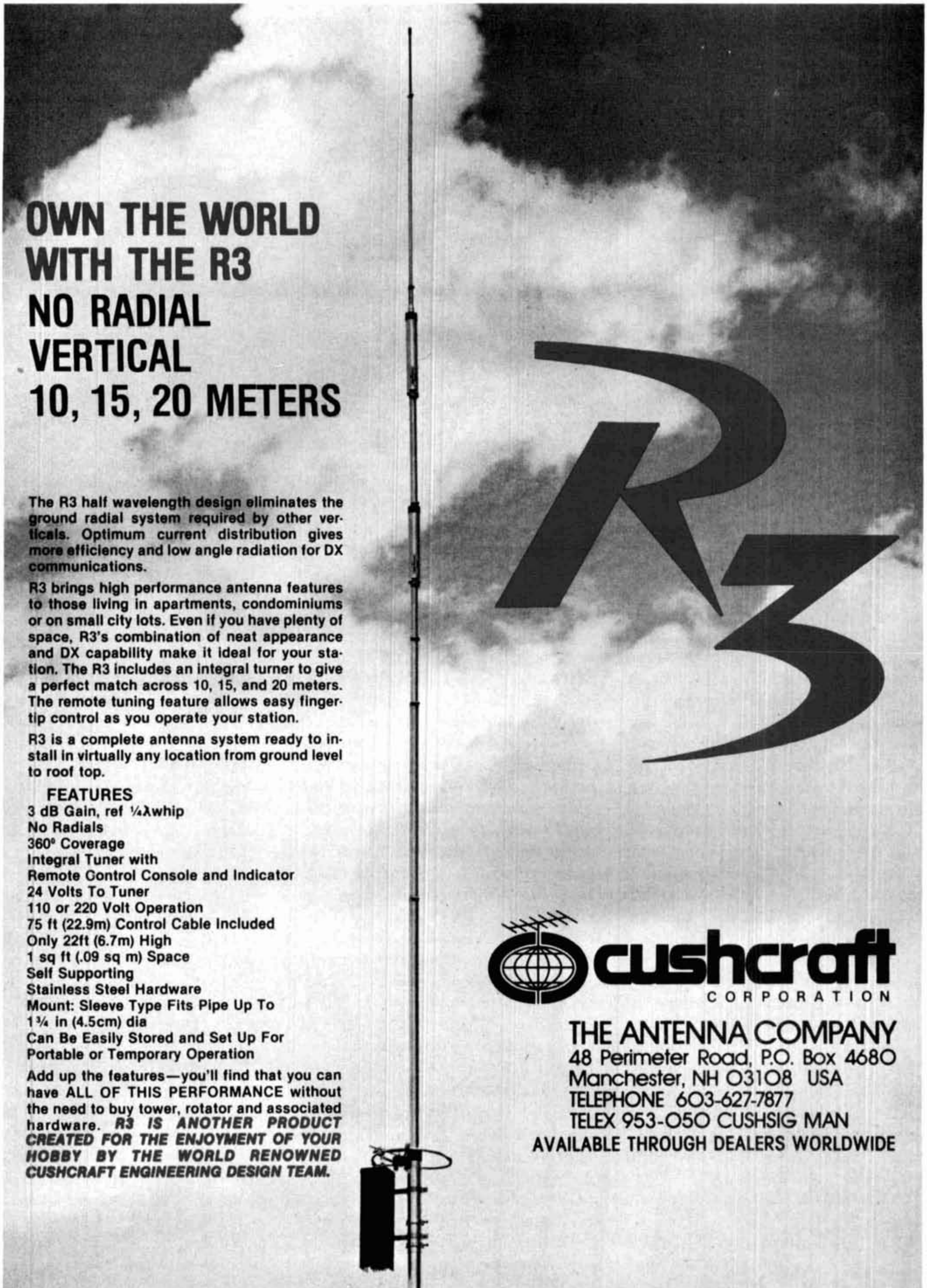
Congratulations to NASA, The ARRL, W5LFL, K6DUE, and many other contributors toward making Owen's space operation possible. A special salute to Vic Clark, W4KFC, who passed away one week too soon to see a dream on which he'd worked so hard finally realized. A most ambitious project, meticulously executed, for the benefit of all—but particularly Amateur Radio.

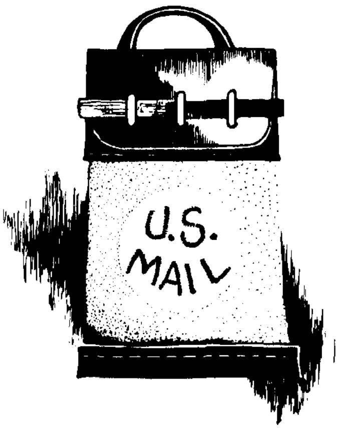
PCB-FILLED DUMMY LOADS DO POSE A THREAT TO AMATEURS, though perhaps not as severe as once feared. A just-completed study by the Centers for Disease Control in Atlanta found less than 2% of the loads tested contained PCB coolant, though a few others did show traces of the dangerous compound. However, tests of the Amateurs who'd been exposed to the PCB-cooled loads showed no abnormal levels in their blood.

Since Any Exposure To PCBs Is Considered Dangerous, Amateurs who have dummy loads, capacitors, or transformers made before PCB's dangers became known should contact the nearest office of the EPA for advice on safe disposal.

THE VOLUNTEER EXAM IS MOVING AHEAD, with appointment of the first regional Volunteer Exam Coordinator likely very soon. Leading the race with a very well thought out proposal is the Anchorage Radio Club, which is anxious to take on the responsibility for the entire state of Alaska. There are also groups or organizations in almost every other part of the country who've indicated strong interest in taking on the VEC job in their areas. In the meantime, the ARRL is still talking about becoming the national VEC.

WARC FREQUENCY ALLOCATIONS WERE ADOPTED BY THE FCC in December, with several items of concern for Amateurs. 1.9-2.0 MHz was allocated to Amateur Radio on a "restricted secondary" basis, with radiolocation primary. AM broadcast will eventually be moving into 1605-1705 kHz, with displaced radiolocation users then going to 160's top end. 220-225 MHz retains Amateur, plus fixed and mobile pending the results of an FCC NTIA working group study. The 902-928 MHz band seems to have a variety of potential users, but the FCC did turn down industry pleas that it also include a secondary land-mobile allocation.


OWN THE WORLD
WITH THE R3
NO RADIAL
VERTICAL
10, 15, 20 METERS
The R3 half wavelength design eliminates the ground radial system required by other verticals. Optimum current distribution gives more efficiency and low angle radiation for DX communications.
R3 brings high performance antenna features to those living in apartments, condominiums or on small city lots. Even if you have plenty of space, R3's combination of neat appearance and DX capability make it ideal for your station. The R3 includes an integral turner to give a perfect match across 10, 15, and 20 meters. The remote tuning feature allows easy fingertip control as you operate your station.
R3 is a complete antenna system ready to install in virtually any location from ground level to roof top.
FEATURES
3 dB Gain, ref ¼λwhip
No Radials
360° Coverage
Integral Tuner with
Remote Control Console and Indicator
24 Volts To Tuner
110 or 220 Volt Operation
75 ft (22.9m) Control Cable Included
Only 22ft (6.7m) High
1 sq ft (.09 sq m) Space
Self Supporting
Stainless Steel Hardware
Mount: Sleeve Type Fits Pipe Up To
1¾ in (4.5cm) dia
Can Be Easily Stored and Set Up For
Portable or Temporary Operation
Add up the features—you'll find that you can have ALL OF THIS PERFORMANCE without the need to buy tower, rotator and associated hardware. R3 IS ANOTHER PRODUCT CREATED FOR THE ENJOYMENT OF YOUR HOBBY BY THE WORLD RENOWNED CUSHCRAFT ENGINEERING DESIGN TEAM.
R3
cushcraft
CORPORATION
THE ANTENNA COMPANY
48 Perimeter Road, P.O. Box 4680
Manchester, NH 03108 USA
TELEPHONE 603-627-7877
TELEX 953-050 CUSHSIG MAN
AVAILABLE THROUGH DEALERS WORLDWIDE



comments

photovoltaics

Dear HR:

WD8AHO's article, "Photovoltaic Cells: a Progress Report" (December, 1983, page 52), brought to mind painful recollections of the early 1960s when I bought 300 0.4 × 0.8 silicon cells surplus for fifty bucks. I say "painful" because I soldered the little buggers in a series-parallel arrangement. I thought I would go blind and also learned that the little pieces of silicon would fracture easily. When most of the 300 were finally soldered, I had the pleasure of getting all of 2 + watts output on a sunny day. Still, it was great fun after the drudge work of putting it together was done and it did make a nice battery charger. After several years of operation, the unit busted up on my move from San Francisco to Oakland. Too bad — there are more sunshine/hours in Oakland.

The 'breeder concept" photo in the article (**fig. 1**) made me whistle. There must be at least 3000 square feet of panels. That would mean about a *million* of my 0.4 × 0.8 chips (ouch), and at 1960's prices, a cost (even at surplus) of over $150,000, all for about 6 kW output!

Since I've been out of touch with that scene for over twelve years, it's apparent there has been a great deal of progress.

Your article really rekindled my interest.

Nubar Tashjian, K6KVX
Oakland, California

Dear HR:

I don't understand WD8AHO's claim that solar cells at $4.00 per watt will pay back in less than one year. (See "Photovoltaic Cells: A Progress Report," December, 1983, page 52.)

Energy from our local electric company costs $\frac{1W}{1000} \times \$0.052 = \$0.52 \times 10^{-4}$ each hour at the 1 watt rate. So, for the $4.00 cost of a 1-watt solar cell, I could buy 76,923 hours of electric energy at the 1-watt rate. Averaging six hours per day, as one might use a solar cell, I could buy that power from the local electric company for 12,820.5 days or about *35.1 years.*

The added expense for storage batteries (and inverters?) makes the break-even time even longer. I don't know the life expectancy of solar cells, but I would be surprised to break even within the span of human lifetime.

Martin Sample
Tuolumme, California

As Mr. Sample suggests, the question of when photovoltaics will become cost competitive with local power companies is, to some, a good reason not to get involved in photovoltaics.

Photovoltaics is not *for everyone, and certainly not for anyone who measures payback solely in economic terms. But a modest photovoltaics system can meet the needs of the Amateur who wants an economical, uninterrupted supply of power for his or her ham shack, for remote operations, and in emergencies or natural disasters.*

Every day we read of billion-dollar cost overruns, unexpected delays, and unacceptable workmanship in the development of new power plants. These problems suggest that in the years to come, electricity is likely to cost more, not less. It's reasonable to expect that by the time photovoltaic power reaches the 100 megawatt level and the cost has dropped to below $4 per watt, the payback period of PV's — partly because of power company rate increases — will be reduced to less than one year and be competitive with utility rates.

With a life expectancy of 30 years or more, photovoltaics today offer a readily available source of dependable power at a reasonable price.

Paul J. DeNapoli, WD8AHO
Livonia, Michigan

As far as Amateurs today are concerned, perhaps the following letter says it best . . .

Dear HR:

I fail to see how solar energy can have a payback of less than three and one-half years. At $10 per peak watt, and four hours per day peak sun time, I calculate only 1460 watt hours per year. At 7 cents per kWh, this equates to a payback of 10 cents per year — which would take 100 years!

WD8AHO is clearly talking about energy payback only (the energy required to build a cell), not the cost of manufacture. I am truly excited about the prospects of solar energy and finally put cells on my sailboat to keep the batteries trickle-charged. You can't beat PVs when you can't get power any other way, but let's be honest about the cost to the consumer.

R.F. Bruninga, WB4APT
Bowie, Maryland

auto-dialer chip

The MD-22 chip necessary for construction of K2MWU's "State-of-the-Art Auto-Dialer" (December, 1983, page 21) will again be available in mid- to late February.

Readers who have had difficulty in obtaining this part should contact CES, Inc., P.O. Box 2930, Winter Park, Florida 32790. (305) 645-0474.

short circuit

RTTY and the Atari™

In the article, "RTTY and the Atari™ Computer," on page 38 in the July, 1983, issue of *ham radio*, the lower left pinout of the XR2211 chip should be labeled 12. It was omitted from **fig. 3** though discussed in the text on the following page under the subhead "terminal unit construction adjustments."

AEA Brings You The AMTOR Breakthrough

We are pleased to announce three new AMTOR products. Our new software package that will allow you to operate AMTOR with your CP-1 is called AMTORTEXT™. A complete hardware terminal unit and AMTORTEXT software plug-in cartridge for the Commodore 64 computer is called the MICROAMTOR PATCH™. We also have new applications software packages for the AMT-1 and Commodore 64 or VIC-20 computers.

NEW AMTORTEXT™

AMTORTEXT™ is a LOW COST software package that will allow the CP-1 and Commodore 64 computer to be used as a multi-mode AMTOR TERMINAL. Compare the outstanding FEATURES and PRICE of the AT-64 (AMTORTEXT for Commodore 64) to the competition:
• KEYBOARD OVERLAY instructions (eliminates constant referral to manual) • STATUS INDICATORS on screen • Easy to follow MENU • ARQ, MODE A- MASTER OR SLAVE • FEC MODE B • MODE L (LISTEN TO MODE A) •SPLIT SCREEN with 2000 CHARACTER TYPE AHEAD transmit buffer • WORD MODE for error correcting with DEL KEY until space or CR is sent • REMOTE ECHO shows characters transmitted as they are validated by other station • easy entry of your SELCALL for automatic response to ARQ calls • BREAK-IN MODE to interrupt sending station • LTRS/FIGS REVERSE for assistance in MODE L sychronizing • TEN MESSAGE BUFFERS OF 256 CHARACTERS EACH • AMTOR timing synced to host computer internal CRYSTAL OSCILLATOR • PROGRAMMABLE TRANSMIT DELAY can be saved to tape • AUTOMATIC PTT • POWERED BY HOST COMPUTER • includes INTERFACE CABLE for AEA model CP-1 COMPUTER PATCH™.

The AMTOR software TIMING ROUTINES have been written by Peter Martinez, G3PLX (father of AMTOR) which means you can be sure of having NO SYNCHRONIZING problems with other AMTOR stations adhering to the established international AMTOR standard. PROPER SYNCHRONIZATION is an ABSOLUTE must for AMTOR!

$89.95 List $69.95* C-64 AMTORTEXT

NEW MICROAMTOR PATCH™

MICROAMTOR PATCH™ is a NEW LOW-COST, HIGH-PERFORMANCE AMTOR SOFTWARE/HARDWARE computer interface package. The MICROAMTOR PATCH (model MAP-64) INCORPORATES AMTORTEXT software (described above) for the Commodore 64 computer. All circuitry and software is incorporated on a single, plug-in cartridge module featuring the following: •TRUE DUAL CHANNEL MARK AND SPACE MULTI-STAGE 4 POLE, CHEBYSHEV ACTIVE FILTERS • AUTOMATIC THRESHOLD CORRECTION for good copy when one tone is obliterated by QRM or SELECTIVE FADING • EASY, POSITIVE TUNING with TRIPLE LED INDICATOR • NOT a low-cost, easily "pullable" phaselocked loop detector!!! • SWITCH SELECTED 170 Hz or WIDE SHIFT on receive • AUTOMATIC PTT • demodulator circuitry powered by your 12 VDC supply to AVOID OVERLOADING HOST COMPUTER and for maximum EMI ISOLATION • EXAR 2206 SINE GENERATOR for AFSK output • SHIELDED TRANSCEIVER AFSK/PTT INTERFACE CABLE PROVIDED • FSK keyed output.

The MicroAmtor Patch is structured for easy upgrading to the AEA CP-1 Computer Patch™ advanced interface unit without having to buy a different software package! Simply unplug the external computer interface cable (supplied with the MicroAmtor Patch) from the MicroAmtor Patch and plug it into the Computer Patch.

$149.95 List $129* MAP64
$239.95 / $199.95* MAP-64/2

The Model MAP-64/2 incorporates the C-64 MBATEXT™ PROM on the same board with AMTORTEXT for low cost RTTY/CW/ASCII/AMTOR operation.

AMT-1

Shown with optional AMT-1 Console Stand, COMM-64 with CRT Monitor and cassette recorder (Not included)

The **AMT-1** is the DEFINITIVE AMTOR TERMINAL UNIT which all future AMTOR units will be measured against. All you need for full AMTOR operation is a dumb ASCII terminal (or personal computer and emulation software) and a normal HF transceiver and antenna. With the AMT-1 you will receive the following features: •SENSITIVE FM DEMODULATOR • FOUR POLE ACTIVE RECEIVE FILTER • TOTAL CONTROL FROM KEYBOARD or by COMPUTER PROGRAM CONTROL • 16 LED PANADAPTOR TYPE TUNING INDICATOR • CRYSTAL CONTROLLED AFSK MODULATOR • RECEIVE/TRANSMIT standard RTTY • TRANSMIT MORSE CW • MORSE RECEIVE field installable option • AUTOMATIC PTT • 13 front panel LED STATUS INDICATORS • all METAL ENCLOSURE for maximum RFI immunity • operates from your 800 ma 12 VDC power source.

$589.95 List $499.95* AMT-1

Applications software for C-64 or VIC-20

AEA also offers an applications software package for the Commodore VIC-20 (model AMT-1/VIC20-1) or 64 computer that is resident on a plug-in PROM CARTRIDGE and includes the INTERFACE CABLE to go between the computer and the AMT-1. KEYBOARD OVERLAY instructions are also included for easy operation without the instruction manual. The COMM-64 program (model AMT-1/C64-1) offers SPLIT SCREEN OPERATION with ten MESSAGE BUFFERS. It also offers UNATTENDED OPERATION with automatic MESSAGE RECORDING and AUTOMATIC STATION INDENTIFICATION.

$89.95 List $69.95*

*SUGGESTED AMATEUR DISCOUNT PRICE THROUGH PARTICIPATING DEALERS ONLY

PLEASE SEND AEA CATALOG

Name

Address

City

State Zip

Advanced Electronic Applications, Inc.

P.O. BOX C-2160 • LYNNWOOD, WA 98036 • (206) 775-7373 • Telex: 152571 AEA INTL

frequency synthesis
by VXO harmonic selection

Quieter than a PLL, it generates all frequencies between 5 and 6 MHz

This article describes a modification of an old method of frequency synthesis.[1] Its chief advantage over the earlier scheme is that it can synthesize all possible frequencies over the output range, rather than being limited to a set of discrete frequencies. Its stability, determined by the stability of a single VXO, is comparable to that of other synthesizers.

block diagram

The basis for the system is a variable crystal oscillator — a VXO consisting of a 100-kHz frequency standard crystal which is continuously "pulled" from 100 to 100.2 kHz (see **fig. 1**). The VXO output frequency is divided by ten and fed to a pulse generator. Here a short pulse is formed with a PRF continuously variable over the range 10 to 10.02 kHz, directly controlled by the VXO. A bandpass filter passes the 500th through 600th harmonics of the pulse, producing a "comb" with about 10 kHz spacing which moves continuously upward about 10 kHz as the VXO frequency is increased. If the 500th harmonic is selected, its frequency will move continuously from 5000 to 5010 kHz. Then if the 501st harmonic is selected, its frequency will move continously from 5010 to 5020.02 kHz and so on. In this way we may obtain all possible frequencies in the range from 5 to 6 MHz.

In order to select one harmonic and reject all others, it is necessary to employ a filter having a bandwidth considerably less than 10 kHz. Consideration of spurious frequency problems leads to the use of a SSB crystal filter in the 9 MHz region. I selected an 8.83 MHz filter because I intend to use a 9 MHz beating oscillator to heterodyne the synthesizer into the ham bands, and I do not wish to invite trouble. The VFO and first mixer form a superhet with an 8.83 MHz IF sharp enough to pass just one "tooth" of the "comb." The IF beating against the same VFO in the second mixer restores the selected "tooth" to its original frequency, *exactly*. Drift in the VFO has no effect on the output frequency. As the VFO is tuned continuously in one direction, succeeding "teeth" are selected, interspersed with regions of zero output. The VFO is calibrated in terms of output frequency so that the appropriate "tooth" is selected. The output frequency is then adjusted to the desired value by adjusting the VXO frequency. If this adjustment causes the IF to reject the "tooth," slight retuning of the VFO will bring it back into the filter passband. The selection indicator is a meter which indicates whether or not a "tooth" is passing through the filter. It reads either zero or about 2/3 scale, corresponding to the absence or presence of an output signal, respectively.

theory of operation

Assume a VXO is continuously "pulled" from f_0 to a higher frequency, f_1. We may multiply the frequency by any integer, M, and divide the frequency by any integer, N. The output frequency will vary from

$$f_L = \frac{M}{N} f_0 \tag{1}$$

to

$$f_H = \frac{M}{N} f_1 \tag{2}$$

By Frank Noble, W3MT, 10004 Belhaven Road, Bethesda, Maryland 20817

For continuous coverage, the pulling range of **fig. 2(A)** must be equal to the separation between adjacent harmonics of $\frac{f_0}{N}$, **fig. 2(B)**, or

$$\frac{M}{N}(f_1 - f_0) = \frac{f_0}{N} \quad \textbf{(3)}$$

so that

$$M = \frac{f_0}{f_1 - f_0} \quad \textbf{(4)}$$

Substituting **eq.4** in **eq.1**:

$$N = M\frac{f_0}{f_L} = \frac{f_0^2}{f_L(f_1 - f_0)} \quad \textbf{(5)}$$

Comparing **fig. 2(C)** with **fig. 2(A)**, note that

$\frac{M+1}{N}(f_1 - f_0)$ is larger than

$$\frac{M}{N}(f_1 - f_0) \quad \textbf{(6)}$$

so M in **eq. 4** is the *minimum* value which will provide continuous coverage. Larger values will produce progressively increasing overlap.

practical considerations

If a standard SSB crystal filter is used, the harmonic spacing must be of the order of 10 kHz to allow adequate rejection of neighboring harmonics. Hence

$$\frac{f_0}{N} = 10^4 \quad \textbf{(7)}$$

and

$$N = f_0 \times 10^{-4} \quad \textbf{(8)}$$

Substituting **eq. 8** in **eq. 5**:

$$M = f_L \times 10^{-4} \quad \textbf{(9)}$$

Now the desired value of f_L is 5×10^6, so that

$$M = 500 \quad \textbf{(10)}$$

AT-Cut crystals will not achieve values of M as small as 500, using capacitance tuning. This amount of pull may be obtained with inductive tuning, but extreme care must be taken, especially with the coil, to retain stability. The frequency, f_0, must exceed 10 MHz so that reasonable values of inductance may be used. This leads to the requirement of large frequency division, N, an additional complication. An incidental advantage is that the tuning linearity is better than for capacitance loading.

If we use the 100 kHz 5 degree X Cut commonly employed for frequency standards, a value of $M = 500$ may be obtained with capacitance tuning. The temperature stability will be poorer than for AT crystals, but a crystal oven will solve this problem.

In any case, the percentage drift of the output frequency will be identical to the percentage drift of the crystal.

circuit description

Fig. 3 shows a detailed circuit diagram for one form of the synthesizer.

The first stage, the VXO, uses an LF353N for U1A in a power design[2] and substitutes a large variable capacitor having "midline" plates to improve the tuning linearity. (SLF or even more radical plate shapes would be preferable if available.) A fast-rising square wave is formed by U1B, suitable for driving the divide by ten IC, U2. The very fast rising square wave output of U2 is differentiated by a short time-constant RC circuit. The negative-going pulse is clipped by the

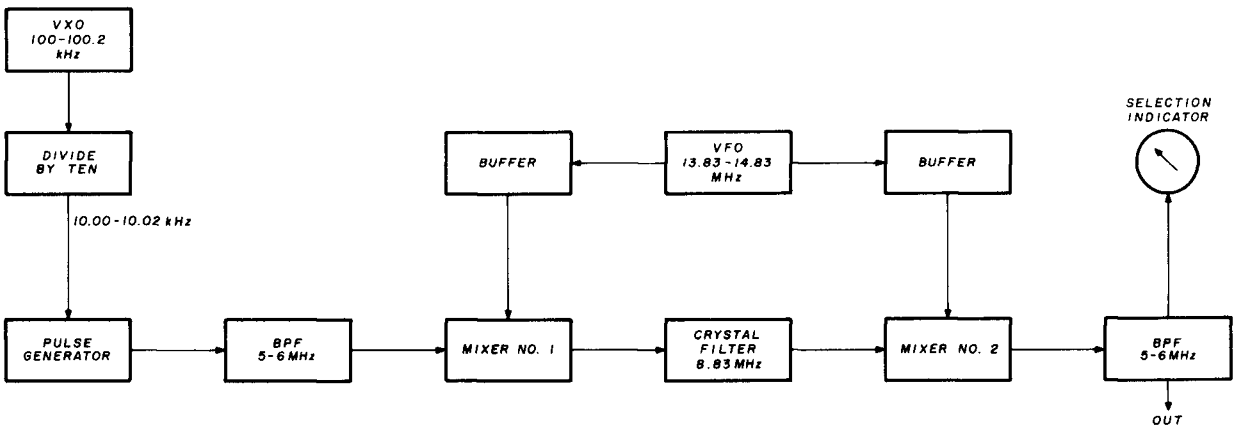


fig. 1. One possible arrangement for the synthesizer. See text for a discussion of the relationships between the various frequencies.

diode, so that the input to Q1 is a short positive pulse with a PRF continuously variable from 10 to 10.02 kHz. The source of Q1 is biased at +6 volts so that only the narrow part of the pulse near its peak is amplified. The tuned circuit in the output of Q1 is resistively loaded to pass 5-6 MHz, selecting the desired "comb." Q2 raises the comb level. Its output is also broadbanded by resistive loading. A link on the Q2 output coil drives one input of diode ring mixer No. 1 through an attenuator which provides a 50-ohm source for all frequencies. The second input to the mixer is supplied by the VFO buffer, Q9, having a source impedance of about 50 ohms at the VFO frequency. (This is not ideal. It would have been better to increase the output of Q9 and use an attenuator to provide 50 ohms at all frequencies.)

The output of the first mixer is terminated in 50 ohms for all frequencies. *This is the most critical termination*. It drives FL-1 through a series resistor, forcing a termination of less than 600 ohms, which is roughly what the filter requires. The output termination is about 400 ohms. (We observe that passband flatness, vital to SSB, is not important in this application; consequently, termination requirements have been eased.) Since the filter is very sharp, the output circuit of IF amplifier U3 has high Q and large L/C to achieve high gain. Q3 is an RC amplifier for driving FL-2 with a source impedance of somewhat less than 680 ohms. This filter is also terminated in somewhat less than 680 ohms. It drives emitter-follower Q4.

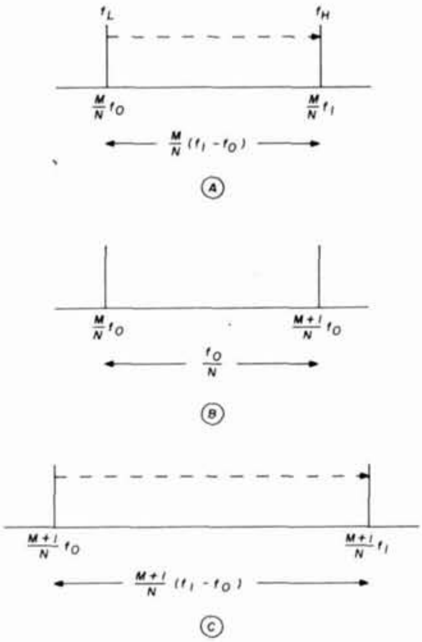
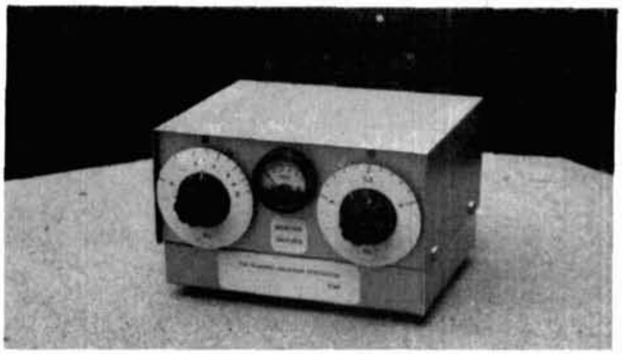


fig. 2. Diagram for determining the relationships between frequencies, multipliers, and divisors.



Left, VXO direct drive dial calibrated in kHz. Center, selection indicator meter. Right, VFO reduction drive dial calibrated in 100 kHz steps.

The output impedance of Q4 approximates 50 ohms at all frequencies to match one input of the second mixer. A separate VFO buffer, Q8, drives the other input. The critical output of the second mixer sees 50 ohms at all frequencies. U4 is an amplifier, broadbanded by the 50 ohm half-wave filter at its output. The input to amplifier U5 is fairly clean. The signal is made larger by U5 and further laundered by the bandpass filter at its output. Q5 is an emitter follower to reduce the output impedance to about 50 ohms at the "HI" output. An L network followed by a quarter-wave filter reduces the output voltage and impedance and further improves the waveform at the "LO" output. Q6 is another emitter follower used to prevent distortion generated by the diode rectifier from reaching the RF outputs. The rectified and filtered output of Q6 is used to drive the selection indicator, a miniature 1 milliampere meter. The VFO, Q7, is a Hartley oscillator using a good coil and source degeneration to obtain good stability and waveform. It must not drift over ±1 kHz per hour — otherwise it could drift the desired "tooth" out of the filter slot. The VFO tuning capacitor has semi-circular plates for good tuning linearity. It is driven by a reduction dial to make the tuning less critical.

mechanical details

Except for the portion between the U4 link and the outputs, the circuit is contained in a metal enclosure (standard chassis No. 1) measuring 3 1/4" H × 7 1/2" W × 5 7/8" D, (9 cm × 19 cm × 15 cm) Radio Shack No. 270-229 (see photo 2). A second standard chassis (No. 2) contains the portion after the U4 link, a 12-volt regulated power supply (150 mA), and a converter employing a 12.5 MHz crystal oscillator to beat the synthesizer output up into the 40-meter band. No attempt was made to miniaturize chassis No. 2 because it rests on a shelf under the operating table, out of the way. The coils in chassis No. 2 are surplus 5/8-inch slug-tuned bakelite units mounted in shield

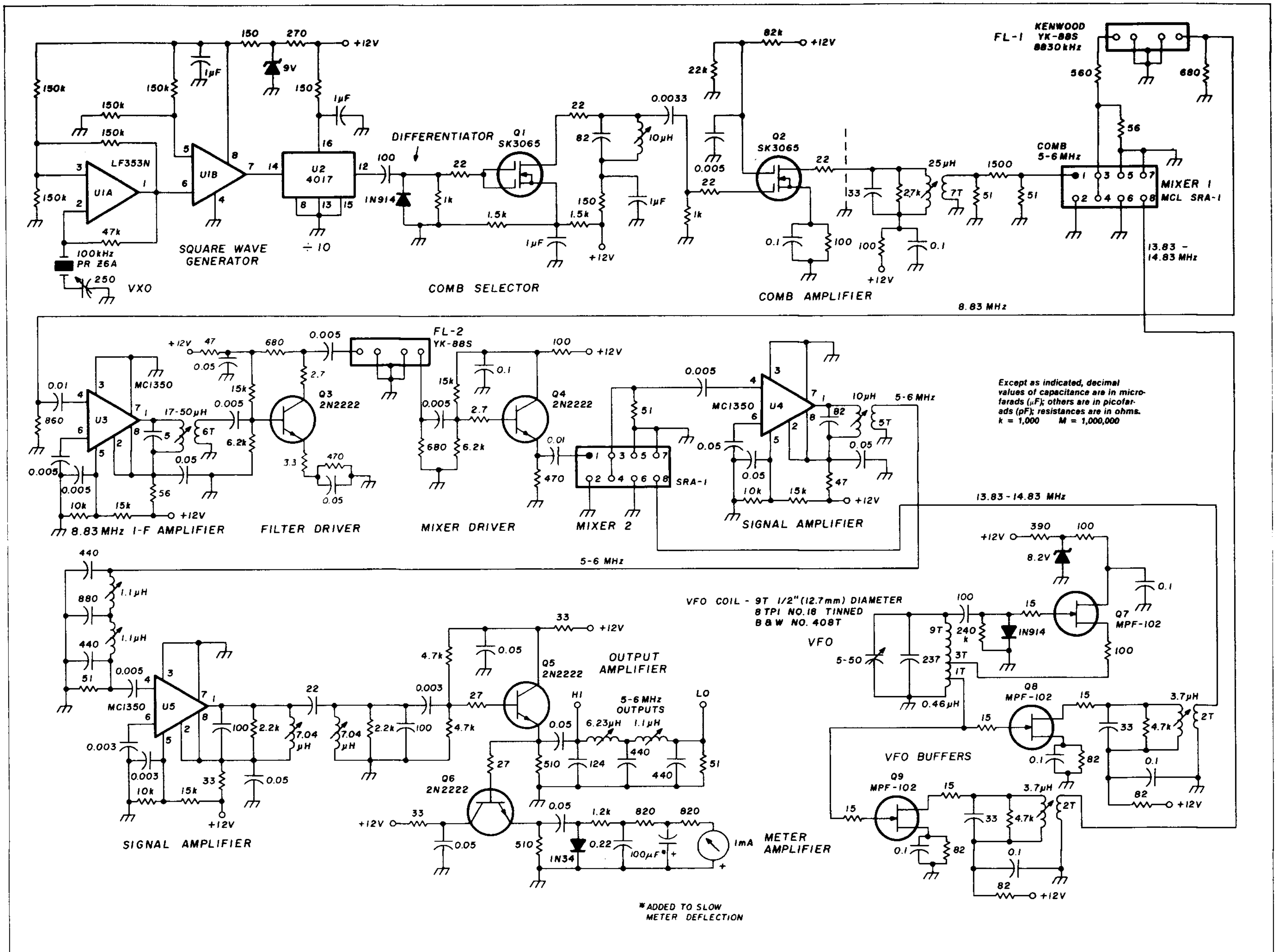
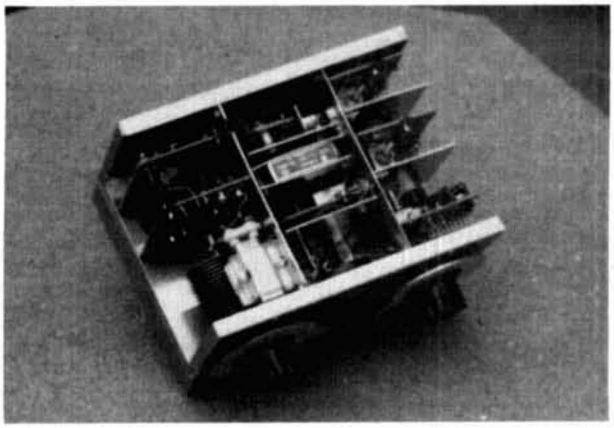


fig. 3. Detailed circuit diagram for one form of the synthesizer. Details of the design and suggestions for improvement are contained in the text.



Left, front-to-back, VXO through comb amplifier. Right, front-to-back, VFO and VFO buffers. Center, balance of circuitry through U4 output; front-to-back, Mixer No. 1, FL-1, U3, Q3, FL-2, Q4, Mixer No. 2, U4.

cans. The coils in chassis No. 1 are 3/8-inch slug-tuned ceramic unshielded forms made by Miller. A shielded cable containing power supply leads and the DC for the selection indicator interconnects the two chassis. The RF interconnection is made by means of coax cable.

Chassis No. 1 is divided into three main shielded compartments by means of two aluminum shields running front-to-back. The left compartment contains U1 through Q2. The right compartment is subdivided into three shielded sections and contains Q7, Q8, and Q9, front-to-back. The remainder of the circuit through U4 is contained in the center section. Most of the circuits are supported on perfboard placed parallel to the front panel. Push-in terminals are used where required. Care is taken to be sure that the mixer grounds are of low inductance and resistance — otherwise balance will be degraded. Similarly, the connections to the crystal filter grounds and case should be very solid, and the input and output circuits well separated and shielded; otherwise, unwanted signals may bypass the filters. The VXO tuning shaft is directly driven by a knob calibrated in kHz. The VFO shaft is driven by a 6:1 reduction drive dial calibrated in 100 kHz steps. Coax cable running below the bottom plate carries the RF interconnections between the shielded compartments. For mechanical reasons, the ends of the coax are exposed. To correct this, a shield resembling an inverted chassis is placed below the bottom plate and secured with metal spacers. This shield also raises the knobs above the table, increasing the ease of tuning.

comments

The writer's experience with low frequency VXO circuits is limited to one crystal of ancient manufacture. Before proceeding further, a prospective builder should experiment to be sure his 100 kHz crystal will pull 200 Hz. (Note that the exact fre-

quencies do not matter; the difference between the maximum and minimum frequencies must be at least 200 Hz.) If this much pull cannot be obtained, the circuit will have to be re-designed using the equations contained above.

It should be clear that this is a first model which is certainly not of optimum design. Its defense is that it presents no surprises. The second crystal filter, used to reduce noise generated in the IF amplifier and to increase the out-of-band attenuation, may not be needed. The filters associated with U5 and Q5 could be simplified and improved. The crystal could be placed in an oven for better stability. Finally, the VFO reduction drive should have a higher ratio, (preferably 100:1, to ease the tuning); if not, some form of electrical bandspreading could be used.

acknowledgements

I appreciate the interest in this project expressed by many fellow hams. In particular, I wish to express my gratitude to Dick Schellenbach, W1JF, and Skip Marsh, W6TFQ, for their help and encouragement.

references

1. E.W. Pappenfus, "Electronics for Communication Engineers," *Markus and Zeluff*, McGraw-Hill, first edition, 1952, pages 377-378.
2. "Frequency Measurements," *ARRL Handbook*, American Radio Relay League, 1982, page 16-13.

ham radio

elliptic lowpass audio filter design

Use standard 88 and 134 mH inductors for deep attenuation filter response

The elliptic lowpass filter is frequently used by the Radio Amateur for speech filtering because of its sharp selectivity, and many articles have been published on this particular application.[1-6] Unfortunately, the audio filter design procedures currently used by the Amateur are derived from engineering texts, and therefore are more suited to commercial practices. For example, the commercial filter designer develops his design based on a particular cutoff frequency and impedance level, and then orders the inductors from an inductor manufacturer. Capacitors are obtained from electronic distributors, measured, and then paralleled as required to get the design values within the specified tolerance. In Amateur applications, in which requirements are less stringent, variations in cutoff frequency and impedance level can be exchanged for more convenient component values. The Amateur also places greater importance on being able to use an inexpensive source of standard-value inductors than does the commercial designer. This is because the Amateur usually builds only one or two filters and therefore cannot take advantage of the large-volume discount prices available to the commercial designer.

In the discussion that follows, a simple design procedure for passive LC audio elliptic lowpass filters that use inexpensive 88 and 134-mH inductors is presented.

common filter types

The two most frequently used filter types in Amateur Radio practice are the Chebyshev and the elliptic. Both can be designed for any level of passband ripple; the elliptic is more versatile because it also can be designed for any level of stopband attenuation.[7] Also, the attenuation rise of the elliptic can be made much more abrupt than the Chebyshev.

In RF harmonic filtering, attenuation greater than 40 dB one octave from the cutoff frequency is usually adequate; a 7th-degree Chebyshev design is most suitable because its response provides more than 42 dB attentuation at twice the cutoff frequency and it has a simple ladder configuration (four shunt capacitors alternating with three series inductors). However, for speech filtering applications, it is important that the filter attenuation rise as quickly as possible to 40 dB or more. Consequently, the 7th-degree elliptic design is preferred over the Chebyshev. Greater than 40 dB of attenuation occurs at a frequency only 1.2 times the cutoff frequency of an elliptic filter compared to two times the cutoff frequency of a Chebyshev design.

Fig. 1 shows the schematic diagram and the typical attenuation response of a 7th-degree elliptic filter. A family of elliptic designs is available that shows 45 to 65 dB of stopband attenuation and uses the *same value of inductance for L4 and L6.* This means that only two different inductance values are needed (L2, and L4, L6). One value can be the fixed 88 or 22-mH value of the standard surplus inductor, and the other can be obtained from a modified 134 or 33.5-mH inductor.

inductor types

The two inductor types suitable for the elliptic filter construction are shown in **fig. 2**. Both types (one potted) have molybdenum-permalloy cores and the optimum frequency range is from 300 Hz to 20 kHz. Both types have two windings that can be connected either in parallel or series aiding. **Fig. 3** shows the inductors with instructions for connecting the windings in series or parallel.

The unpotted inductor has an inductance of 134 or 33.5 mH in the series or parallel connection, respectively. The potted inductor has values of 88 or 22 mH in the series or parallel connection. The potted induc-

By Ed Wetherhold, W3NQN, Honeywell, P.O. Box 391, Annapolis, Maryland 21404

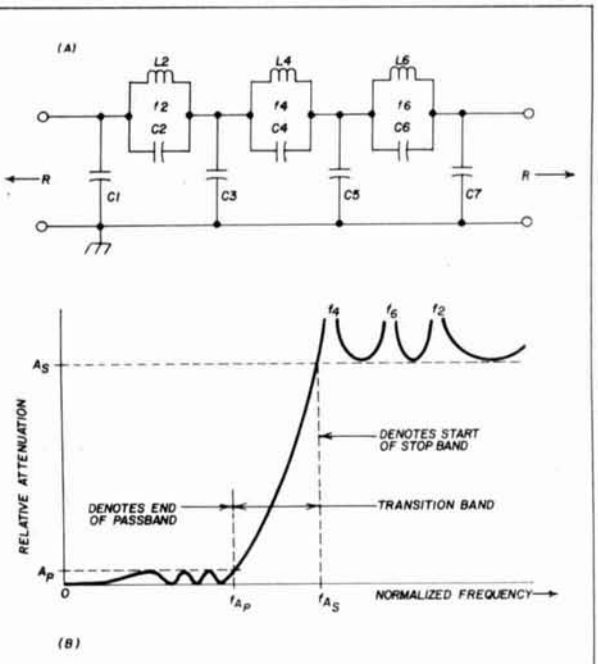


fig. 1. Elliptic 7th-degree lowpass filter. (*A*) Schematic diagram including component designations. (*B*) Attenuation response.

tor is designed for mounting on a flat surface by inserting a ¼-inch diameter stud through a hole and then by placing a Tinnerman mounting clip over the stud to secure the inductor. The center inductor in **fig. 2** is shown with a Tinnerman mounting clip.

Since turns cannot be removed from the potted inductor to vary the inductance, it must be used as is in applications requiring a 22 or 88-mH value. Because turns can be removed from the unpotted inductor, many different elliptic designs are possible, and eight different designs have been selected and calculated for stopband attenuation (A_s) levels ranging from 45.6 to 64.5 dB. The total turns needed to be removed from the unpotted inductor for these eight designs varies from eight to one hundred turns. Procedures and equations for calculating the total turns to remove for any inductance value that may be needed are given in **appendix A**.

7th-degree elliptic lowpass filter

The maximum amplitude of the passband ripple (A_p) (see **fig. 1B**) is less than 0.11 dB for these designs. The cutoff frequency is designated f_{A_p} and is defined as that frequency at which the attenuation first exceeds the A_p level. The normalized value of f_{A_p} is unity, and all other frequencies are referenced to it. The start of the stopband is denoted by f_{A_s} and occurs where the minimum stopband attenuation (A_s) is first achieved. The band of frequencies between the end of the passband and the start of the stopband is called the transition band. It is desirable to minimize the transition band for best filter selectivity. An indication of the degree of selectivity is the f_{A_s}/f_{A_p} ratio — the smaller the ratio, the more selective the filter. Since the normalized value of f_{A_p} is unity, the normalized value of f_{A_s} indicates filter selectivity. The f_{A_s} values in the eight designs vary from 1.2 to 1.37. Note: selectivity and higher stopband attenuation are tradeoffs.

In audio filtering applications, a passband ripple of less than 0.2 dB (as found in the eight designs), is sufficiently low and won't be discussed further.

L2-C2, L4-C4, and L6-C6 resonant circuits produce attenuation peaks in the response at f_2, f_4, and f_6 (see **fig. 1**). If these attenuation peaks are correctly placed, the minimum stopband attenuation will theoretically never drop below the A_s value.

simplified design procedure

Table 1 lists all filter parameters: inductances, reflection coefficients, A_p, f_{A_s}, and A_s. The reflection coefficient, used by filter designers to categorize a specific design, is directly related to A_p. The relationship between R (filter termination impedance) and f_{A_p} is given in columns R and F of **table 1**. R can be calculated if f is known, or vice versa. The L2 and L4, L6 columns list two inductance values which correspond to the series or parallel connections of the inductor windings.

Table 2 lists the normalized component values and frequencies of the same eight designs in **table 1**. This data is used to calculate the actual component values and frequencies of the filter after the termination resistance and cutoff frequency are selected.

The designs in **tables 1** and **2** are keyed to each other either by the design number or by the *L2/L4*

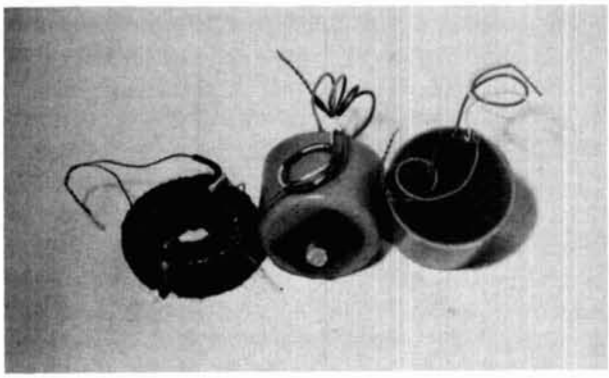


fig. 2. The two inductor types used in constructing the filter. Each has two windings which can be connected in series or parallel. The large unpotted inductor (L2) has a maximum inductance of 134 or 33.5 mH and the potted inductors (L4 and L6) have 88 or 22 mH for the series or parallel connections, respectively. All inductors are shown with their leads in the parallel connection. One of the potted inductors is shown with a Tinnerman mounting clip.

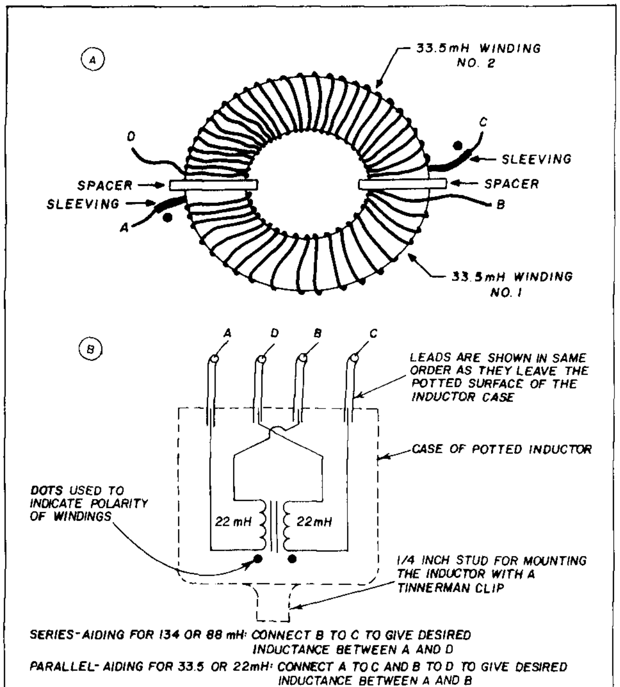


fig. 3. These diagrams show the lead designations of the unpotted 134 mH and potted inductors with instructions for connecting the two windings in series or parallel: (A) unpotted 134 mH; (B) potted 88 mH.

ratio. These ratios range from 1.25 to 1.50, and correspond to $L2$ values from 110 to 132 mH (in the series-aiding connection) or from 27.5 to 33.0 mH (in the parallel-aiding connection). The purpose of each table will be explained before demonstrating the design procedure.

Before selecting a design from **table 1**, the cutoff frequency and the approximate impedance level must first be selected. Because the cutoff frequency is usually more critical, its value is fixed, and R is calculated using the equations under column R or by using the graph in **fig. 4**. The "A" designs are best suited for cutoff frequencies below 2 kHz, while the "B" designs are best for cutoff frequencies above 2 kHz.

In most cases, an exact match between design and circuit impedance is not possible. However, resistive matching pads (see **appendix C**) can be used if the difference between the circuit and filter impedances is less than about 30 percent. For greater impedance differences, matching transformers must be used. The disadvantage of not being able to select a specific and independent filter termination impedance is a consequence of using fixed inductor values, worthwhile because standard-value surplus inductors can be used. The filter performance parameters are next reviewed to see if they are fully satisfactory. If, for example, a minimum stopband attenuation exceeding 55 dB is required, then only designs 1 through 3 should be considered. After a design is selected from **table 1**, and normalized values of the same numbered design in **table 2** are scaled to the impedance level and cutoff frequency.

design example

To design a speech filter that has a 3 kHz cutoff frequency and a source and load impedance of 500 ohms, a typical procedure would consist of the following steps:

(a) Follow the 500-ohm line across the graph in **fig. 4** until it intersects with the slanted lines in the vicinity of 3 kHz; design 8B provides the closest match. If a lower or higher cutoff frequency is required, the filter impedance level must be changed to correspond to the new cutoff frequency. If the new filter impedance is within 30 percent of 500 ohms, resistive padding can be used to match the filter to the 500-ohm system. For greater impedance differences, suitable matching transformers must be used to prevent excessive signal amplitude loss (see note 1).

(b) Refer to **table 1** to check the performance parameters of design 8B. If f_{A_S} and A_S are satisfactory, then design 8B can be used. For design 8B, $L4 = L6 = 22\ mH$, $L2 = 33\ mH$, $L2/L4 = 1.500$, and $R.C. = 8.06$ *percent*.

(c) Find the exact f_{A_p} cutoff frequency for $R = 500$

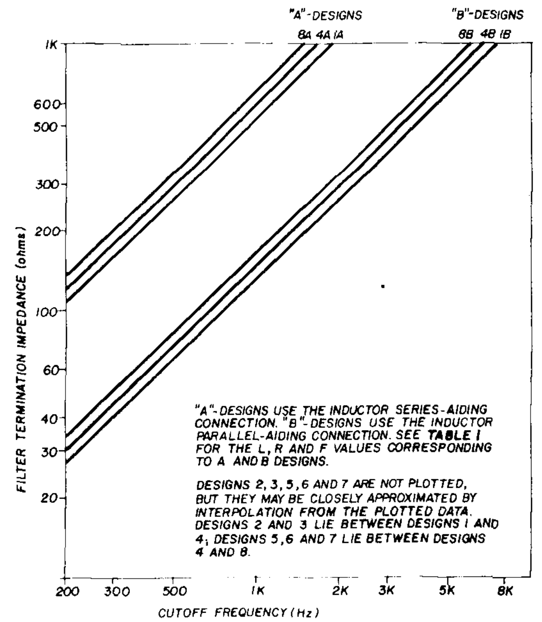


fig. 4. Lowpass filter cutoff frequency versus termination impedance for some of the filter designs in *table 1*.

AEA Brings You The RTTY Breakthrough

NEW MBATEXT™ $109.95 List / $89.95* VIC-20 MBATEXT or C-64 MBATEXT

MBATEXT™ is the most advanced MBA (Morse, Baudot, ASCII) software plug-in cartridge available for the VIC-20 or Commodore 64 computer. Compare our outstanding features and price to the competition.

• KEYBOARD OVERLAY instructions to avoid constant referral to the manual • RTTY and ASCII SPEED ESTIMATE MODE • BREAK-IN CW MODE •QSO BUFFER RECORD TOGGLE •WORD PROCESSOR style insertion, deletion, and correction in TEXT EDIT MODE • CW AUTO SPEED TRACKING plus SPEED LOCK • BREAK-IN BUFFER that is easy to use • Low speed FARNSWORTH CW TRANSMISSION (between 5 and 14 WPM) • RE-TRANSMIT RECEIVED TEXT DIRECTLY without need of disk or cassette • DISK, CASSETTE, OR PRINTER storage of message and QSO buffers • RECEIVE AND TRANSMIT 5-99 WPM MORSE • 10 SOFT-PARTITIONED™ MESSAGE (OR TEST) BUFFERS • WORD WRAP • TIME OF DAY CLOCK • PRECOMPOSE SPLIT SCREEN OPERATION • STATUS INDICATORS on screen • EASY START-UP by simply typing SYS 44444 or SYS 33333 • DEDICATED FUNCTION KEYS for quick operation • Ability to IMBED CONTROL FUNCTIONS in type-ahead buffer • WORD OR CHARACTER mode • SELECTABLE BAUDOT UNSHIFT ON SPACE (USOS) •SEND/RECEIVE 60, 67, 75, 100, 132 WPM BAUDOT PLUS 100, 300 BAUD ASCII • RTTY BLANK-FILL and MORSE BT option for idle transmit periods • AUTOMATIC PTT • computer control of TONE REVERSE • MASTER MENU, COMMAND MENU, and ORTIONS MENU makes MBATEXT™ easy to use with no prior experience • INCLUDES CABLE TO INTERFACE WITH AEA model CP-1 COMPUTER PATCH™ • POWERED BY HOST COMPUTER.

NEW MICROPATCH™

MICROPATCH™ IS A NEW LOW-COST, HIGH-PERFORMANCE Morse, Baudot and ASCII SOFTWARE/HARDWARE computer interface package. The MICROPATCH™ model MP-20 or MP-64 incorporates the complete MBATEXT software ROM (described above) for either the VIC-20 or Commodore 64 computers. All circuitry and software is incorporated on a single, plug-in cartridge module featuring the following: • TRUE DUAL CHANNEL MARK AND SPACE MULTI-STAGE 4 POLE, CHEBYSHEV ACTIVE FILTERS • AUTOMATIC THRESHOLD CORRECTION for good copy when one tone is obliterated by QRM or SELECTIVE FADING • EASY, POSITIVE TUNING with TRIPLE LED INDICATOR • NOT a low-cost, low-performance phase-locked loop detector!!! • SWITCH SELECTED 170 Hz or WIDE SHIFT on receive • 800 Hz multi-stage active CW FILTER • AUTOMATIC PTT • RTTY ANTI-SPACE • demodulator circuitry powered by external 12VDC (not supplied) to AVOID OVERLOADING HOST COMPUTER and for maximum EMI ISOLATION • EXAR 2206 SINE GENERATOR for AFSK output • SHIELDED TRANSCEIVER AFSK/PTT INTERFACE CABLE PROVIDED • PLUS or MINUS CW KEYED OUTPUT • FSK keyed output.

The Micropatch is structured for easy upgrading to the AEA Computer Patch ™ advanced interface unit without having to buy a different software package! Simply unplug the external computer interface cable (supplied with the Micropatch) from the Micropatch and plug it into the Computer Patch.

$149.95 List $129.95*
MP-20 or MP-64

COMPUTER PATCH™

COMPUTER PATCH™ is the name of our most advanced computer interface equipment for Morse, Baudot, ASCII, or AMTOR operation. The CP-1 will allow you to patch most of the popular personal computers to your transceiver when used with the appropriate AEASOFT™ TU software such as AEA MBATEXT, AMTOR TEXT™, or the MBATEXT RESIDENT ON THE MICROPATCH units. AEA also offers a full feature software package for the Apple II, II plus and IIE; TRS-80 Models I, III and IV; and the IBM-PC. The CP-1 will also work with certain other computers using commonly available software packages.

The CP-1 offers the following advanced and high quality features: • HANDSOME ALL METAL ENCLOSURE FOR MAXIMUM RF IMMUNITY • DUAL CHANNEL, MULTI-STAGE ACTIVE MARK AND SPACE FILTERS • AUTOMATIC THRESHOLD CORRECTION • RECEIVE 170 HZ FIXED OR 100-1000 HZ VARIABLE SHIFT • 800 HZ multi-stage CW FILTER • PRE—LIMITER AND POST-LIMITER FILTERS • SERIAL RS-232 FIELD INSTALLABLE OPTION • 117 VAC WALL ADAPTOR SUPPLIED • PLUS (+) and MINUS (-) CW OUTPUT JACKS • MAGIC EYE STYLE BAR GRAPH TUNING INDICATOR • SCOPE OUTPUT JACKS • NORMAL/REVERSE front panel switch • MANUAL (override) PTT switch • VARIABLE THRESHOLD for CW • ANTI-SPACE RTTY • KEY INPUT JACK for narrow shift CW ID on RTTY, CW practice, or keyboard bypass.

The CP-1 is made in the U.S. with high quality components including double-sided glass epoxy through-hole plated boards, complete with solder mask and silk screened parts designators.

$239.95 List $199.95* CP-1

PACKAGE SPECIALS

$239.95*

Combine the VIC-20 or COMM-64 MBATEXT™ software with the CP-1 at time of purchase and you receive a SPECIAL PACKAGE PRICE. NOW the best RTTY COMPUTER INTERFACE SYSTEM is available at prices comparable only to vastly inferior systems.

CP-1/20 (CP-1 with VIC 20 MBATEXT) CP-1/64 (CP-1 with C-64 MBATEXT)

*SUGGESTED AMATEUR DISCOUNT PRICE THROUGH PARTICIPATING DEALERS ONLY

WE ALSO STOCK AMPLIFIERS AND ANTENNAS FOR RTTY

HENRY RADIO 54 YEARS OF SERVICE

Henry Radio

2050 S. Bundy Dr., Los Angeles, CA 90025 (213) 820-1234
931 N. Euclid, Anaheim, CA 92801 (714) 772-9200
Butler, Missouri 64730 (816) 679-3127

TOLL FREE ORDER NUMBER: (800) 421-6631
For all states except California
Calif. residents please call collect on our regular numbers

149

AEA Brings you the Breakthrough!

ohms from the equation in column f of **table 1**: $f = 6.0137(500) = 3007\ Hz$. Use 3007 Hz as the cutoff frequency and $R = 500\ ohms$ in the following calculations. (By a fortunate coincidence, in this particular case both the f and R values are virtually identical with the desired values. This will not always be the case, and it is up to the ingenuity of the filter designer to find an optimum combination of parameters that best satisfies the design requirements. This is one of the things that makes filter designing a challenge.)

(d) Calculate the capacitance and inductance scaling factors, C_S and L_S where R and f are in ohms and Hertz:

$$C_S = 1/(R \cdot f) = 1/(500)(3007) = 0.6651 \cdot 10^{-6}$$
$$L_S = R/f = 500/3007 = 166.3 \cdot 10^{-3}$$

(e) Calculate the L and C component values by multiplying the normalized component values of design 8, **table 2**, by the C_S and L_S scaling factors. Frequencies are obtained by multiplying the normalized frequencies of design 8, **table 2**, by the cutoff frequency, 3007 Hz. The component and frequency values obtained are:

C1 = 0.1289f $(0.6651 \cdot 10^{-6})$ = 0.0857 μF
C2 = 0.02561f $(0.6651 \cdot 10^{-6})$ = 0.01703 μF
C3 = 0.2084f $(0.6651 \cdot 10^{-6})$ = 0.1386 μF
C4 = 0.1291f $(0.6651 \cdot 10^{-6})$ = 0.0859 μF
C5 = 0.1819f $(0.6651 \cdot 10^{-6})$ = 0.1210 μF
C6 = 0.09836f $(0.6651 \cdot 10^{-6})$ = 0.0654 μF
C7 = 0.08079f $(0.6651 \cdot 10^{-6})$ = 0.0537 μF
L2 = 0.19845H $(166.3 \cdot 10^{-3})$ = 33.0 mH
L4,6 = 0.1323H $(166.3 \cdot 10^{-3})$ = 22.0 mH
f_{A_p} = 1.000 (3007 Hz) = 3007 Hz

table 1. Lowpass filters: inductor values and L2/L4 ratios with related parameters for selected 7th-degree elliptic designs where $L4 = L6$. [For filter construction using two potted 88-mH inductors and one modified 134-mH inductor.]

design no.		L2/L4 ratio	L2 (mH)	L4,6 (mH)	R.C. (%)	A_p (dB)	f_{A_s}	A_s (dB)	R (ohms)	f (Hz)
1	A	1.250	110.0	88	15.36	0.1037	1.3703	64.50	0.5279(f)	1.894(R)
	B		27.5	22					0.1320(f)	7.577(R)
2	A	1.300	114.4	88	12.80	0.07171	1.3166	59.16	0.5515(f)	1.8133(R)
	B		28.6	22					0.1379(f)	7.2532(R)
3	A	1.333	117.3	88	11.56	0.05842	1.2888	56.19	0.5689(f)	1.7578(R)
	B		29.3	22					0.1422(f)	7.0313(R)
4	A	1.380	121.4	88	10.23	0.04571	1.2573	52.61	0.5947(f)	1.6817(R)
	B		30.4	22					0.1487(f)	6.727 (R)
5	A	1.400	123.2	88	9.77	0.04164	1.2458	51.25	0.6060(f)	1.6501(R)
	B		30.8	22					0.1515(f)	6.6005(R)
6	A	1.440	126.7	88	8.98	0.03517	1.2258	48.77	0.6293(f)	1.5890(R)
	B		31.7	22					0.1573(f)	6.356 (R)
7	A	1.460	128.5	88	8.64	0.03257	1.2169	47.64	0.6411(f)	1.5597(R)
	B		32.1	22					0.1603(f)	6.239 (R)
8	A	1.500	132.0	88	8.06	0.02829	1.2012	45.56	0.6652(f)	1.5034(R)
	B		33.0	22					0.1663(f)	6.0137(R)

Notes:

1. The unpotted inductor (L2) has two 33.5 mH windings that can be connected in series or parallel aiding to give 134 or 33.5 mH, respectively. The potted inductors (L4 and L6) have two 22 mH windings which can be connected in series or parallel aiding to give 88 or 22 mH. **Fig. 3** shows the series and parallel aiding connections.

2. See **fig. 1A** for the schematic diagram and **fig. 1B** for the typical attenuation response of the above filter designs. See **table 2** for the normalized component values and frequencies.

3. To obtain the L2 inductance values, remove an equal number of turns from both windings of the unpotted inductor in accordance with the following equations (as shown in **appendix A**):

(a) for all "A" designs, $T_s = 532 - 45.957\sqrt{L_s}$, where T_s is the number of turns removed from each winding (total turns removed = $2 \cdot T_s$, and L_p = the desired L2 inductance in the series-aiding connection.

(b) for all "B" designs, $T_p = 532 - 91.914\sqrt{L_p}$, where T_p is the number of turns removed from each winding (total turns removed = $2 \cdot T_p$), and L_s = the desired L2 inductance in the parallel-aiding connection.

For example, for L_s or $L_p = 132\ or\ 33\ mH$, remove four turns from each winding and connect the windings in the series or parallel-aiding connection, respectively.

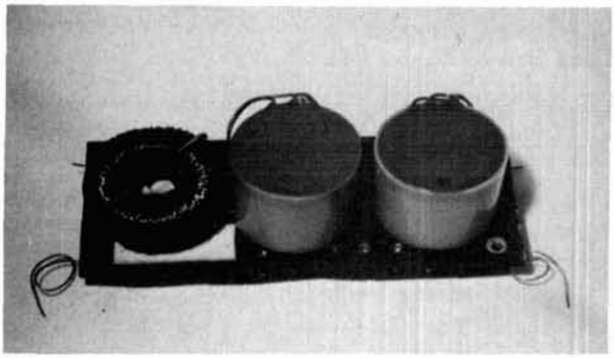
f_{A_s} = 1.201 (3007 Hz) = 3611 Hz
f_2 = 2.233 (3007 Hz) = 6715 Hz
f_4 = 1.218 (3007 Hz) = 3663 Hz
f_6 = 1.395 (3007 Hz) = 4195 Hz
with R = 500 ohms and A_s = 45.6 dB

As a check on the correctness of the values of (C2,L2), (C4, L4) and (C6,L6), the resonant frequencies of these parallel tuned circuits can be calculated and should agree to within about 0.1 percent with the values of f_2, f_4, and f_6 calculated from the scaling procedure.

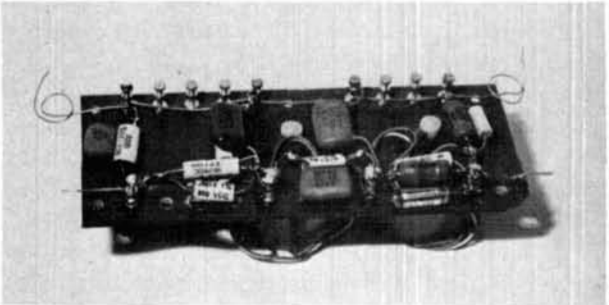
filter construction

Figs. 5A and **5B** are photographs of the completed filter design 8B. The inductors and capacitors are mounted on opposite sides of a 2 x 5-inch terminal board. The unpotted inductor is fastened to the terminal board with 3M Scotch™ tape, and the two potted inductors are mounted with their 1/4-inch mounting studs and Tinnerman clips.

The tolerances of the shunt capacitors (C1, 3, 5, and 7) are not critical, and values within 5 percent of the design values are satisfactory. Two capacitors can be paralleled when necessary to obtain the required value. The calculated values of the resonating capacitors (C2, 4, and 6) should be used only as a guide. This is because the actual resonant frequencies of the three tuned circuits are of primary importance, while the exact values of capacitance are of secondary importance. The 88-mH value of the potted inductors is only nominal, and it can vary as low as 86 mH. It seldom is greater than 88 mH. The winding capacities of the potted inductors in the 88- and 22-mH connections are about 68 and 176 pF, respectively. The winding capacities of the unpotted inductor in the 134- and 33.5-mH connections are about 68 and 148 pF, respectively. The simplest procedure for tuning the three resonant circuits of the elliptic filter is to assemble all the filter com-



(A)



(B)

fig. 5. The photographs of the completed filter show how the inductors and capacitors are mounted on opposite sides of a standard terminal board. The filter assembly can then be mounted in a standard 5 × 4 × 3-inch aluminum mini-box. In (*A*), the unpotted inductor (L2) is on the left followed by L4 and L6. In (*B*), capacitor C1 is on the left. The common ground return wiring is at the top of the terminal board.

table 2. Lowpass filter: normalized component values and frequencies of selected 7th-degree elliptic designs where *L4 = L6*. (Values are normalized for an f_{A_p} cutoff frequency of 1 Hz and 1-ohm terminations.)

design no.	L2/L4 ratio	C 1	C 2	L 2 (Henry)	C 3	C 4	L4&L6 (Henry)	C 5	C 6	C 7	f_{A_s}	f_2	f_4	f_6
		(Farad)			(Farad)			(Farad)						
1	1.250	0.1760	0.01627	0.2083	0.2671	0.07819	0.1667	0.2439	0.05647	0.1438	1.370	2.734	1.394	1.640
2	1.300	0.1611	0.01832	0.2074	0.2495	0.08863	0.1596	0.2251	0.06487	0.1254	1.317	2.582	1.338	1.564
3	1.333	0.1535	0.01964	0.2063	0.2402	0.09552	0.1547	0.2152	0.07047	0.1155	1.289	2.501	1.309	1.524
4	1.380	0.1448	0.02141	0.2042	0.2293	0.1051	0.1480	0.2036	0.07830	0.1038	1.257	2.407	1.276	1.478
5	1.400	0.1416	0.02214	0.2033	0.2252	0.1091	0.1452	0.1993	0.08165	0.09931	1.246	2.372	1.264	1.462
6	1.440	0.1360	0.02357	0.2014	0.2179	0.1172	0.1398	0,1916	0.08835	0.09126	1.226	2.310	1.243	1.432
7	1.460	0.1335	0.02426	0.2004	0.2145	0.1211	0.1373	0.1881	0.09169	0.08758	1.217	2.283	1.234	1.419
8	1.500	0.1289	0.02561	0.19845	0.2084	0.1291	0.1323	0.1819	0.09836	0.08079	1.201	2.233	1.218	1.395

Notes:
1. **Fig. 1A** shows the interconnections of the capacitors and inductors. **Fig. 1B** shows the cutoff frequency and attenuation peaks corresponding to the f_1 and $f2$, $f4$, and $f6$ values.
2. The normalized data for the filter design numbers in this table also apply to similarly numbered designs in **table 1**.

ponents except for the resonating capacitors, C2, C4 and C6. Connect the partially assembled filter between a signal source and a resistive load, both having the design impedance of the filter. Set the signal source to the frequency of the first resonant circuit to be tuned, and monitor the filter output voltage across the load resistor with an AC VTVM. Resonate the inductor of the first resonant circuit with a calibrated capacitor decade. Resonance will be indicated by a minimum reading on the AC VTVM. Read the capacitance required for resonance from the capacitor decade, and then place this value of capacity across the inductor using as many paralleled capacitors as required. Repeat the same procedure for the other two resonant circuits. Using this procedure, it is possible to tune the resonant circuits to within 0.25 percent of the design frequency values.

For optimum stopband performance, the ground leads of C1, 3, 5, and 7 must be independent of each other to minimize any common ground impedance.

testing the filter

Fig. 6 shows the measured filter attenuation compared with the computer-calculated response. Close agreement between measured and calculated responses in the pass and transition bands indicates that a good filter design and assembly procedure were used. The lower-than-expected attentuation peaks at f_2, f_4, and f_6 are because of a common ground impedance in the ground leads of the four shunt capacitors. If separate ground leads are used from the shunt capacitors, the peak attenuation levels can be increased by more than 10 dB. This will cause the measured minimum attenuation A_S levels to increase slightly.

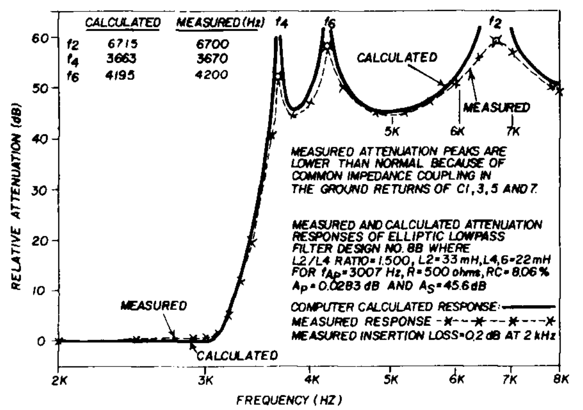


fig. 6. Calculated and measured attenuation responses of the 3-kHz filter design example.

The passband insertion loss is only 0.2 dB. This low value is due to the relatively high-Q inductors in the 3 kHz to 8 kHz frequency range. For much lower cutoff frequencies, the inductor Q's will be lower and the insertion loss will be higher.

obtaining surplus inductors

The potted 88-mH inductors have been provided to the author at no charge by the C & P Telephone Company of Maryland for distribution to those Radio Amateurs wishing to build audio filters. The 134-mH inductors were purchased by the author and are being offered at cost to those wishing to build the filter designs described in this article. Your request for inductors should be addressed to me and accompanied by a description of your filtering application and a 4 × 9-1/4 inch SASE.

summary

Until now, the Radio Amateur has been hindered in using high-performance audio lowpass filters due to the lack of a simplified design procedure and a source of high-Q and inexpensive inductors. This article explains how these problems have been solved. By using computer-aided calculations, designs from a special family of elliptic lowpass filters have been derived that can use two surplus potted 88-mH inductors and one unpotted 134-mH inductor.

Data was tabulated for eight 7th-degree elliptic lowpass designs suitable for the audio frequency range, and a simplified design procedure was demonstrated by designing and building a 3-kHz, 500-ohm lowpass filter. Comparisons were made between the measured and computer-calculated responses to show that the design and construction procedures were valid. It was explained how these design procedures usually result in non-standard impedance levels, and how this inconvenience can be alleviated by using padding resistors or inexpensive matching transformers. A source of surplus inductors for the filter construction was given, and a procedure was explained for deriving an equation for modifying the unpotted inductor for a specific inductance.

acknowledgement

The author gratefully acknowledges the assistance of Mike Barge of Honeywell for performing the computer calculations required in deriving the elliptic filter designs used in this article. The author is also grateful to Joseph Gutowski of EWC, Inc., Harold Mitchell, N0ARQ, of 3M Electronic Products Division, Rex Cox, formerly of Honeywell, and Frank Noble, W3MT, for their review of and comments on the article manuscript before it was submitted for publication.

appendix A

For a series-aiding connection calculate the total number of turns, T_o, as follows:

(a) Measure the original inductance, L_o, with the windings connected in series-aiding (SA) using an inductance bridge. An indirect method of inductance measurement is to resonate the inductor with a precisely known capacitance (± 0.5 percent) while measuring the resonant frequency with a digital frequency counter.[9] Calculate the inductance from the equation:

$$L_{(mH)} = 25.33/(f^2C) \quad \textbf{(1)}$$

where f and C are in kHz and μF.

Use coupling capacitors of approximately 500 pF each to isolate the tuned circuit from the signal generator and the AC VTVM.

(b) Remove 50 turns from each winding and connect the windings in series aiding. Measure the modified inductance, L_r.

(c) Calculate $T_o = 100 \cdot R/(R - 1)$ **(2)**

where $R = \sqrt{L_o/L_r}$
and T_o = original number of turns on the unmodified inductor
L_o = original inductance (mH) in the series-aiding (SA) connection
L_r = inductance (mH) for the SA connection after 100 turns were removed

For example, if $L_o = 134\ mH$ and $L_r = 110\ mH$ for 50 turns removed from each winding, then $R = 1.10371274$ and $T_o = 1064$.

The unique value of T_o is used to find the equation that gives the total number of turns to be removed from any inductor (of the same type) in order to obtain a specific inductance.

$$T_s = 0.5\ (T_o - S\sqrt{L_s}\,) \quad \textbf{(3A)}$$

where $S = (T_o - T_r)/\sqrt{L_r}$ **(3B)**
and T_s = number of turns to remove from each winding to obtain L_s
L_s = desired inductance (mH)
T_o = previously determined number of turns on the unmodified inductor
T_r = total turns removed to get L_r
L_r = inductance (mH) when T_r turns are removed

Example: a 134-mH inductor has a $T_o = 1064$, with $L_r = 110$ for $T_r = 100$

$$S = (1064 - 100)/\sqrt{110} = 91.914$$

then $T_s = 0.5\ (1064 - 91.914\sqrt{L_s})$

$$= 532 - 45.957\sqrt{L_s}$$

For example, find T_s to get 132 mH from the 134-mH inductor.

$$T_s = 532 - 45.957\sqrt{132} = 532 - 528.0$$

$= 4$ *turns removed from each winding.*
Total turns removed $= 8$

For a parallel-aiding connection:

$$T_p = T_o/2 - S\sqrt{L_p} \quad \textbf{(4)}$$

where T_o and S were previously defined, and
T_p = number of turns to remove from each winding to obtain L_p
L_p = desired inductance (mH)

$$T_p = 91.914\sqrt{L_p} \quad \textbf{(5)}$$

Find T_p in order to obtain 33 mH from the 134-mH inductor with its windings in the parallel-aiding connection:

$T_p = 532 - 91.914\sqrt{33} = 532\text{-}528.0$
$= 4$ *turns removed from each winding*
Total turns removed $= 8$

appendix B

Equations relating reflection coefficient and A_p:

$$R.C.\ (percent) = 100\sqrt{1 - 0.1^x} \quad \textbf{(1)}$$

where $x = A_p/10$ and A_p is the maximum passband ripple amplitude in dB.

$$A_p(dB) = -10 \cdot \log_{10}(1 - \varrho^2) \quad \textbf{(2)}$$

where ϱ = *percent R.C./100*

For example, if $R.C. = 8.058$ *percent*, then $A_p = 0.0282913\ dB$.

appendix C

determination of filter matching pad resistances

When the source impedance (Z_s) or load impedance (Z_L) is within 30 percent of the termination impedance required by the filter, a single resistor can be placed in series or parallel with Z_s or Z_L to produce the termination impedance required by the filter. The slight loss in signal level can usually be compensated for by simply increasing the volume control on your receiver. For greater impedance differences, a suitable matching transformer must be used (see note 1).

(A) When Z_s or Z_L *is less than* the required filter termination impedance place a resistance *in series* with the Z_s or Z_L so that the sum of the two equals the desired filter termination impedance.

(B) When Z_s or Z_L *is greater than* the required filter termination impedance place a resistance *in parallel* with the Z_s or Z_L so that the parallel combination equals the desired filter termination impedance. If the added parallel resistance is "R_p," then:

$$R_p = (S \cdot F)/(S - F)$$

where S = source impedance and
F = filter impedance with all values in ohms.

For example, if a 500-ohm filter is to be matched to a 350-ohm source and a 600-ohm load, then place a 150-ohm resistor in series with the 350-ohm source, and connect a 3 kilohm resistor in parallel with the 600-ohm load.

Note 1: A large selection of inexpensive audio transformers of different impedances at power levels of 0.075, 0.2, 0.4, and 2-watts output can be obtained from Mouser Electronics, 11433 Woodside Avenue, Santee, California 92071 (714-449-2222). Prices vary from 79 cents to $1.20 for the 0.075 to 0.4-watt levels and $2.30 for the 2-watt level.

references

1. Genaille, "Lowpass Audio Filters for Increased Talk Power," *Electronics World*, September, 1963.
2. Charles R. MacCluer, W8MQW, and Wallace T. Thompson, Jr., WB2NFD, "The Filterflier," *QST*, November, 1965, page 32.
3. Ed Wetherhold, W3NQN, "An Amateur Application of Modern Filter Design," *QST*, July 1966, page 14.
4. "Narrow-band Voice Modulation," *Radio Amateur's Handbook*, 1979 Edition, pages 14-1 to 14-9, ARRL, Newington, Connecticut 06111.
5. G.V. Entwisle, G3MXT, "The G3MXT Third-method Mk2 and Polyphase Mk2 SSB Generators," *Radio Communication*, December, 1981, page 112.
6. Ed Wetherhold, W3NQN, "Simplified Elliptic Lowpass Filter Construction Using Surplus 88-mH Inductors," *Radio Communication*, April, 1983, p. 318.
7. Ed Wetherhold, W3NQN, "Modern Filter Design for the Radio Amateur," *QST*, September, 1969, page 42.
8. Ed Wetherhold, W3NQN, "Inductance and *Q* of Modified Surplus Toroidal Inductors," *QST*, September, 1968, page 36.
9. Harold T. Mitchell, N0ARQ, "88-mH Inductors — A Trap!," *QST*, January, 1983, page 38.

bibliography

Wetherhold, Ed, W3NQN, "Elliptic Lowpass Filters for Transistor Amplifiers," *ham radio*, January, 1981, page 20.

Wetherhold, Ed, W3NQN, "High-performance CW Filters," *ham radio*, April, 1981, page 18.

Wetherhold, Ed, W3NQN, "Lowpass Filters for Amateur Radio Transmitters," *QST*, December, 1979, page 44.

Wetherhold, Ed, W3NQN, "Modern Design of a CW Filter using 88- and 44-mH Surplus Inductors," *QST*, December, 1980, page 14.

Wetherhold, Ed, W3NQN, "UoSAT-OSCAR 9 Bandpass Filter Design," Technical Correspondence, *QST*, July, 1982, page 43.

ham radio

CES INTRODUCES THE NEW 510SA "SMART PATCH"

The State of the Art Simplex Interconnect

Communications Electronics Specialties introduces the CES 510SA "Smart" Simplex Autopatch, with many important new features never available before: • Three digit control codes with user programming. • A sophisticated toll restrict provides positive long distance lock out. • Time-out and COR activity timers with warning beeps and digital programming. • Rotary or DTMF dialing. • Phone line in-use detector prevents interrupting a call in progress, and sends unique CW sequence. • Phone ring detection logic enables unique CW sequence. • Digital programming of the sample rate and width, and noise gate sensitivity control, for easy interfacing with most radios. Simple and direct connections to radio.

Options available: • Smart CW identifier with unique CW messages for each patch function. • FCC type accepted phone line coupler. • Special tone squelch kit to operate patch through repeaters.

CES

The 510SA — the newest advance in interconnect technology, from the innovators at:
Communications Electronics Specialties, Inc.
Post Office Box 507 • Winter Park, Florida 32790
(305) 645-0474 • Toll-free (for orders only): (800) 327-9956

124

FREE! CABLE LOSS CHART IN WINTER CATALOG

NEMAL ELECTRONICS
COAXIAL CABLE SALE

POLYETHYLENE DIELECTRIC

★ RG-8/U 96% shield Mil Spec	($29.95/100) or 31¢/ft
RG11U 96% shield 75 ohm mil spec	25¢/ft
RG-55B/U double shield (RG-58 size) 50 ohm	45¢/ft
★ RG58U mil spec 96% shield	($9.95/100) or 11¢/ft
RG62A/U 96% shield mil spec 93 ohm	12¢/ft
RG174/U min. 50 Ω mil spec	10¢/ft
RG213 noncontaminating 96% shield mil spec	36¢/ft
RG214/U double silver shield 50 ohm	$1.55/ft
RG214/U tinned copper	65¢/ft
RG217/U double shield 50 Ω 5/8" OD	85¢/ft

LOW LOSS FOAM DIELECTRIC

RG-8X (Mini 8) 95% shield	($14.95/100) or 17¢/ft
★ RG8U 80% shield	($17.95/100) or 21¢/ft
RG-8/U 97% shield 11 gu. (eq. Belden 8214)	31¢/ft
RG58U 80% shield	07¢/ft
RG58U 95% shield	10¢/ft
RG59/U 100% foil shield TV type	10¢/ft
RG59/U 70% copper shield	09¢/ft
HEAVY DUTY rotor cable 2-16 ga 6-18 ga	36¢/ft
Rotor cable 2-18 ga 6-22 ga	19¢/ft

Complete line of multiconductor cables available

CONNECTORS MADE IN USA

Amphenol PL-259	79¢
PL-259 push-on adapter shell	10/$3.89
PL-259 and/or SO-239	10/$5.89
Double Male Connector	$1.79
PL-258 Double Female Connector	98¢
PL-259 Silver-Teflon Kings	$1.59 ea
Reducer UG-175 or 176	10/$1.99
UG-255 (PL-259 to BNC)	$2.95
Elbow (M359) UHF Elbow	$1.79
F59A (TV type)	10/$1.99
UG 21 D/U Type N Male for RG8, Amphenol	$3.00
UG-88C/U BNC Male for RG-58, Amphenol	$1.25
UG 273 BNC-PL259 Amphenol	$3.00
3/16 inch Mike Plug for Collins etc. (cutoff)	$1.25

shipping Call or write for Free Catalog
Cable — $3.00 per 100 ft.
Connectors — add 10%, $3.00 minimum.
Orders under $20 add $2 additional plus shipping.
COD add $2.00. Florida Residents add 5%.

NEMAL ELECTRONICS

Dept. H, 12240 N.E. 14th Ave., N. Miami, FL 33161
Telephone: (305) 893-3924

169

The Best Got Better

MODEL 4381 RF POWER ANALYST

This new generation RF Wattmeter with nine-mode system versatility reads...

IN STOCK QUICK DELIVERY

AUTHORIZED BIRD DISTRIBUTOR

Webster associates

115 BELLARMINE
ROCHESTER, MI 48063

191

CALL TOLL FREE
800-521-2333
IN MICHIGAN 313 – 375-0420

AUDIO-FORUM® offers the best in self-instructional foreign language courses using audio cassettes — featuring those used to train U.S. State Dept. personnel in Spanish, French, German, Portuguese, Japanese, Greek, Hebrew, Arabic, Chinese, Italian, and more.

Learn a foreign language on your own!

Free Catalog.

Call **(203) 453-9794**, or fill out and send this ad to –

Audio-Forum
Room 148, On-the-Green
Guilford, CT 06437

Name ______________________

Address ______________________

City ______________________

State/Zip ______________________

111

I am particularly interested in (check choice):
☐ Spanish ☐ French ☐ German ☐ Polish
☐ Greek ☐ Russian ☐ Vietnamese
☐ Bulgarian ☐ Turkish ☐ Hausa
☐ Other ______________________

More Details? CHECK—OFF Page 108

THE ULTIMATE SCANNER RADIO HAS ARRIVED.

Starting today, we're standing the scanner radio on its ear. Because we've forged ahead—*way* ahead—in radio frequency and digital technology.

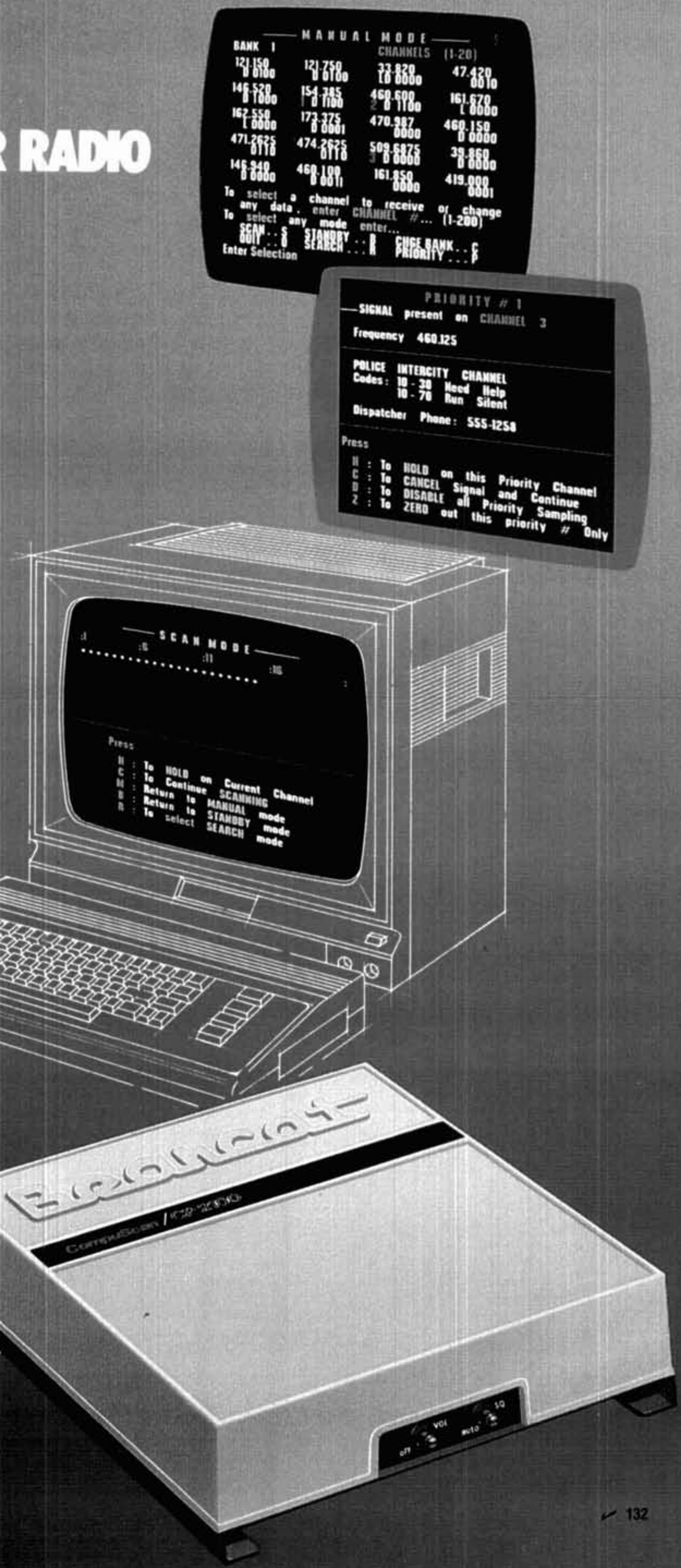
Introducing the Bearcat® CompuScan™ 2100.

It's the first scanner radio designed to put the power of a personal computer to work for you. Now you can scan up to two hundred channels. Stack levels of priority so you'll hear vital calls in order of importance. Automatically search, store and count transmissions for accurate "pictures" of activity within frequency limits you select.

And with automatic video memos you'll know more than you've ever known before. The channel user, special codes, jurisdictions, phone numbers, alternate frequencies—any information you've programmed is automatically displayed when the channel is active.

With ten bands including 70-centimeter, 2, 6 and 10 meter FM Amateur, Military Land Mobile, AM Aircraft, plus Low, High, UHF and UHF-T bands.

For a real earful—and eyeful—see your Bearcat scanner dealer. For the name of the dealer nearest you, just call 1-800-S-C-A-N-N-E-R.



BEARCAT® SCANNERS

132

Electra
Electra Company
Division of Masco Corp. of Indiana
300 East County Line Road
Cumberland, Indiana 46229

high frequency receiver performance

Understanding and specifying good receiver operation

Receiver performance and the means for its specification is a complex and frequently misunderstood topic, for it involves many different and often unrelated parameters, all of which are important to the overall performance of the receiver. (For example, it's no good having exceptional sensitivity if the receiver drifts excessively.) When specifying performance, it is important that all parameters be specified accurately and completely. Many manufacturers and reviewers have been guilty of specifying performance inadequately, with ambiguous and misleading results. For example, the frequently quoted "sensitivity 0.5 μV" is meaningless, and "0.5 μV for 10 dB" is not much better.

It is interesting to note that the importance of some performance parameters (e.g., intermodulation and reciprocal mixing) have only recently been fully appreciated and understood. Also certain receiver design changes have actually been responsible for *reducing* performance: for example, the direct replacement of tubes by bipolar transistors in the late 1960's, and the current widespread use of frequency synthesis, which can introduce spurious receiver responses if not designed with special care.

noise and sensitivity

One of the fundamental concepts underlying receiver performance is that of noise. So before we examine performance parameters — what they mean, how they are specified, and how they can be improved — we'll take a brief look at the physics of noise.

Thermal noise is due to the random movement of particles in the effective impedance at the input to the receiver at ambient temperature. It cannot be avoided (except by cooling the whole antenna system down to near absolute zero) and is even present if a shielded 50 or 75 ohm resistor representing the antenna impedance is plugged into the receiver input. It is given by:

$$V = \sqrt{4kTBR} \qquad (1)$$

where: V = RMS noise voltage
k = Boltzmann's constant
T = temperature in degrees Kelvin
B = receiver bandwidth in Hz
R = resistance/impedance in ohms

For a given antenna impedance and a nominal ambient temperature (taken as 300 degrees K or 27

By J.A. Dyer, G4OBU, Hillview, 27 Bath Road, Ashcott, Somerset, England

degrees C), the only way to reduce the thermal noise is to reduce the receiver bandwidth. For a 50 ohm impedance, ambient temperature of 300 degrees K, and a bandwidth of 3 kHz the above expression works out as:

$$\begin{aligned} V &= \sqrt{(4)(1.38 \times 10^{-23})(300)(3000)(50)} \\ &= 0.05\,\mu V\,(EMF) = -26\,dB\mu V \end{aligned}$$

where a dBμV is a dB relative to 1 microvolt *(EMF)*.

Sensitivity is expressed as the smallest signal required to give a specific signal-to-noise ratio (S/N),* in a particular receiver bandwidth, and in the case of AM, for a given modulation level. In the days of noisy tubes, good sensitivity was hard to achieve without compromising other performance aspects. Now with bipolar transistors and FETs, sensitivities of 0.5 μV for a 10 dB S/N ratio in a 3 kHz bandwidth, can easily be achieved on HF for an SSB or CW signal. As AM is usually specified at 30 percent modulation level, the figure will be 10 dB (3.16 times) worse than the SSB/CW figure; in this case, 1.6 μV (EMF).

Noise factor (NF) can be defined as the ratio of the S/N of a hypothetically perfect (noiseless) receiver to that of a real receiver, which adds its own noise to the thermal noise. Since it is the ratio of two ratios it is independent of bandwidth, temperature, and impedance.

Typical HF spectrum noise voltages within a 3 kHz bandwidth are shown in **fig. 1**. We see at −26 dBμV the thermal threshold noise, and also the receiver noise for a NF of 10 dB, at −16 dBμV. To achieve a S/N of 10 dB a signal will need to be at −6 dBμV or 0.5 μV, which means that an NF of 10 dB is equivalent to a sensitivity of approximately 0.5 μV for a 10 dB S/N in a 3 kHz bandwidth.

However, the most significant conclusions to be drawn from **fig. 1** are concerned with atmospheric noise. This is plotted on **fig. 1** for a quiet area at a quiet time, and is between 5 and 25 dB above receiver noise; consequently for a receiver with a noise figure of 10 dB it is the atmospheric noise, not receiver noise, that limits receiver performance. Indeed the NF could be increased to 15 dB (1μV EMF sensitivity) without loss of performance, except perhaps at 25 to 30 MHz. There is, therefore, no point in reducing the NF below 10 dB — especially as sensitivity can only be obtained at the expense of dynamic effects such as intermodulation. It is also worth noting that claims of 0.15 μV (EMF) for 10 dB S/N (seen recently for an SSB transceiver) are quite impossible. Even a perfect receiver with a 0 dB NF needs 0.16 μV (−16 dBμV) to achieve 10 dB S/N due to the thermal threshold of −26 dBμV.

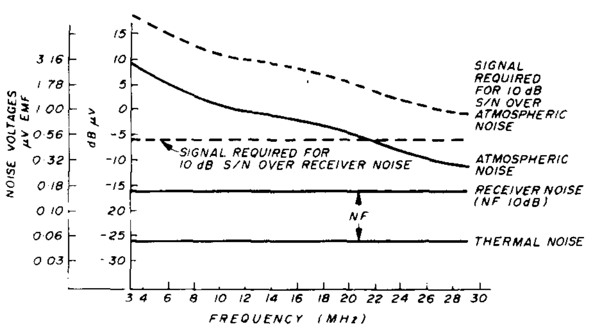


fig. 1. HF spectrum noise in a 3 kHz bandwidth.

From **fig. 1** it can be seen that under real operating conditions a receiver with a sensitivity of 0.5 μV will in fact need between 1 μV (at 30 MHz) and 10 μV (3 MHz) for a 10 dB S/N ratio on HF — and this for a quiet atmosphere (and no QRM)!

The above discussion considered noise voltage in a 3 kHz receiver bandwidth. However, noise is proportional to the square root of the bandwidth. Thus if bandwidth is reduced from 3 kHz to 300 Hz, all noise voltages (thermal, receiver, and atmospheric) drop by a factor of $\sqrt{10}$ or 3.16 times (10 dB). This explains the continuing use of CW in the HF bands; a CW signal can still be copied when SSB would be lost in the noise. In fact, some operators can copy a CW signal with a S/N of around 0 dB, so the advantage over SSB can be as much as 20 dB†. Thus sensitivity for the same (10 dB NF) receiver can be quoted as 0.05 μV for 0 dB S/N in a 300 Hz bandwidth.

Note that all voltages above are EMF (Electromotive Force). Recently it has become common to specify sensitivities and other parameters using potential difference (PD) instead. This practice makes sensitivity figures look twice as good (6 dB better) because, in a matched impedance system, PD is *always* half EMF (see Appendix). Care must therefore be exercised when interpreting receiver specifications; often the distinction is not made clear, usually indicating that PD is intended (see **dynamic range** for explanation).

selectivity

Selectivity used to be achieved by means of distributed tuned circuits in the IF strip, and to obtain good selectivity a low second IF was required (for example, 455 kHz). Selectivity is now usually obtained by means of crystal, mechanical, or ceramic block filters. The ideal filter response has a flat top with low ripple, and steep sides going down to a −70 dB (or

*In fact it's more appropriate to quote signal + noise to noise (S + N/N) or even signal + noise + distortion to noise + distortion (SINAD). Note for an S/N of 10 dB or more there is little difference between the three terms.

†If one considers that the human ear consists of a contiguous series of extremely narrow high Q filters (less than 30 Hz) then perhaps the ear/brain combination always works with a positive S/N ratio for intelligibility. **Editor**

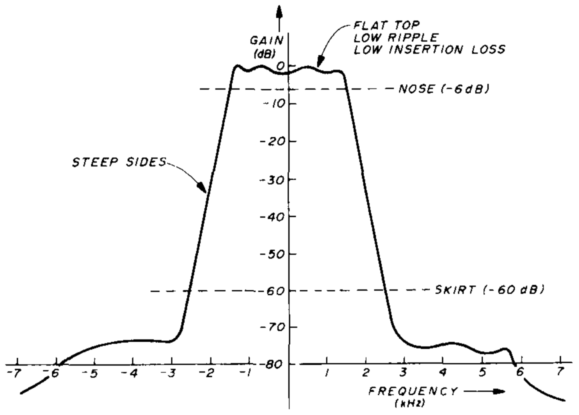


fig. 2. A desirable filter response would include a fast roll-off, low passband ripple and insertion loss, and a high stopband rejection.

greater) stopband, and extending a long way out (see **fig. 2**).

The old constraint of a low second IF no longer applies. In fact, it is easier to design crystal filters for higher frequencies; IFs of 1.4, 1.6, 9 and 10.7 MHz often being used.

Selectivity is usually quoted at the nose bandwidth (6 dB down), and the skirt bandwidth at 60 dB down. Good values for an 8 pole SSB filter are 2.7 kHz and 4.4 kHz, respectively. One measure of filter performance often quoted is the **Shape Factor** (SF), which is the ratio of the skirt bandwidth to the nose bandwidth. The ideal SF is 1:1, and anything less than 2:1 for a 3 kHz SSB filter is considered good.

Mechanical and crystal filters can get quite close to the ideal, and some less expensive ceramic filters give surprisingly good results. Impedance matching into and out of a filter is of great importance and insertion loss (the loss caused by the filter in the middle of the passband) must be made up by amplification (usually less than 10 dB). A typical set of filters for a high grade communications receiver might be 8 kHz (AM), 2.7 kHz (SSB) — often with two asymmetrical filters, one for USB one for LSB — and 1.0 kHz, 300 Hz, and 100 Hz for CW. The trend in Amateur equipment is for the tightest possible SSB filter (2.4 kHz), and often 600 Hz or 300 Hz for CW are used.

The above refers to what could be called the "static" selectivity of the receiver, or the selectivity to a single signal only. For a discussion on dynamic selectivity see the section on **reciprocal mixing**.

As an interesting aside, consider the use of the audio CW filter, often used by the Amateur fraternity in lieu of a good CW filter at the IF. (The best filter of all, of course, is the human brain; a good operator can pick out and copy a weak CW signal in company with numerous other signals because of the difference in tone. Many experienced CW operators prefer to listen in a wide bandwidth and do their *own* filtering even when sharp CW filters are available.) However, the audio image frequency (see **fig. 3**) will also give an output of exactly the same tone, and even the "human filter" will find it impossible to differentiate. But this is exactly the frequency that the audio filter cannot differentiate, either! Also, unless AGC voltage is at least partially audio-derived, strong unwanted signals in the IF passband will reduce the IF gain, hence reducing post-filter dynamic range.

Nevertheless a good multi-pole audio filter can be beneficial, especially if a linear detector is being used. (A product detector is linear; an envelope detector is not.) Also, if a steep-sided SSB filter is available, the audio image can be rejected if the BFO injection is made to coincide with the edge of the passband.

Image (second channel) rejection. In the normal superheterodyning process, a wanted signal (F_S) beats in the mixer with the local oscillator (or synthesizer output) frequency (F_{LO}), and one of the resultant products of the mixing process, usually

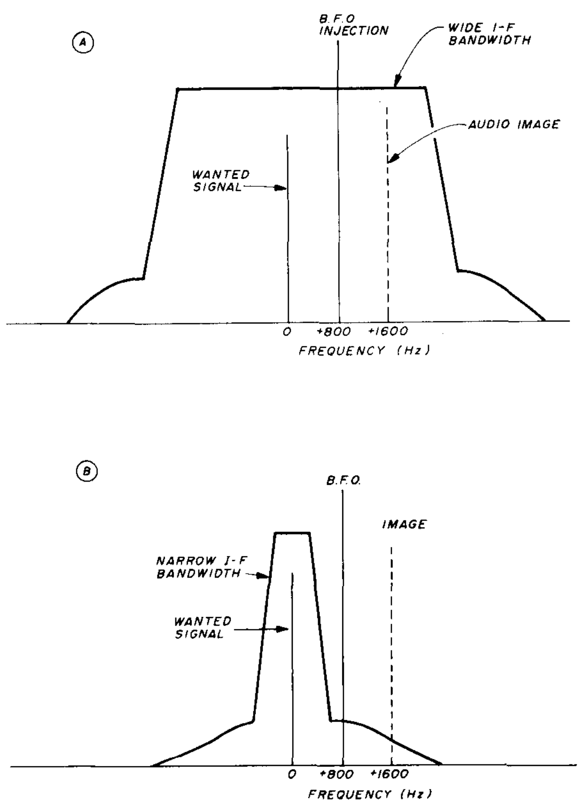


fig. 3. Narrowing the IF bandwidth improves the audio-image rejection: (A) wide I-F bandwidth; (B) narrow I-F bandwidth.

$F_{LO} - F_S$, at the intermediate frequency (IF), is passed by the IF selectivity filter.

However, another frequency called the image or second channel frequency ($F_{LO} + F_{IF}$) also beats with the local oscillator frequency to produce a product at the IF. This frequency must be rejected by some form of RF tuning, either ganged to the "tune" control or using a separate "pre-select" control; or by means of switched bandpass filters, usually automatically switched on synthesized receivers.

As the image frequency is equal to F_S plus twice the IF, the higher the first IF, the further away from F_S will be the image frequency, and the easier it will be to reject. If up-conversion techniques are used, the first IF will be in the range 40 to 90 MHz and the image frequency will also be at VHF and thus can be rejected by a simple 35 MHz low-pass filter at the receiver input.[3]

Image frequency rejection is specified as the ratio in dB of an unwanted signal above 1 μV to give the same output as the received 1 μV signal. 50 dB of rejection is considered poor, while 80 dB or more is desirable.

IF rejection

IF rejection occurs when a strong signal *at a receiver IF* directly breaks through the early stages and into the IF. It is specified in the same manner as image rejection with 80 dB being a desirable number. It should be quoted for all the IFs in a receiver. Often in a double conversion receiver the figure for the second IF is worse than that for the first IF. Good screening is necessary between IF and RF stages, and IF traps in early pre-IF stages can be employed to reduce IF breakthrough. Taken together, IF and image rejection are sometimes referred to as "rejection to external spurii."

dynamic effects

Dynamic interference effects such as intermodulation and cross-modulation have often been largely ignored in the past, and only in the last ten years or so has their true importance been understood. It has to be said that the replacement of tubes by bipolar transistors in the 1960s made the situation worse.* In general, dynamic effects are caused by large off-tune (off frequency) signals that cause the receiver to operate in a non-linear manner. It is these effects (together with reciprocal mixing) that currently determine the performance of the communications receiver rather than the traditional parameters of sensitivity, selectivity, and stability.

dynamic range and intercept point

Dynamic range can be loosely described as the

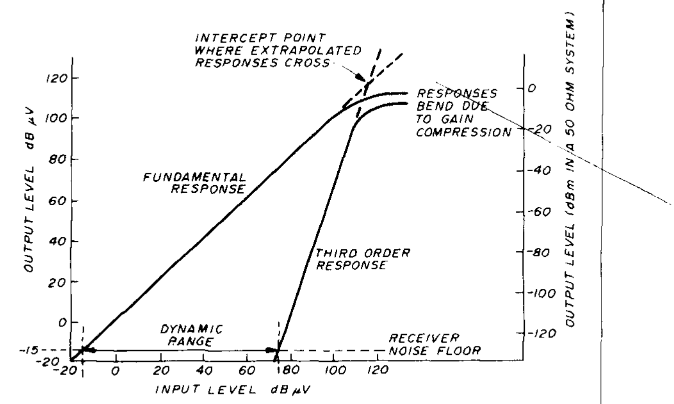


fig. 4. Intercept point is determined from the intersection of the fundamental and third-order response curves.

range of input signals over which dynamic interference effects produce outputs which are not significant (i.e., which are below the noise floor). In order to arrive at a suitable definition for dynamic range, consider the intercept point as shown in **fig. 4**. This occurs because the power level of the dynamic product increases at a greater rate than that for the wanted signal. Second order products increase as the square of the input (twice as many dB), and third order products as the cube (3 times in dB). (Third and second order products will be dealt with in greater detail when discussing intermodulation.)

Dynamic range can then be usefully defined as two-thirds of the difference in level between noise floor and the intercept point, or alternatively as the difference between the fundamental response input level and the third order response input level as measured along the noise floor (see **fig. 4**). These are by no means the only methods of specifying dynamic range, and care must be taken in interpreting manufacturers figures. Using the above method of definition a dynamic range of 90 to 100 dB for 3 kHz bandwidth with an intercept point of 120 to 140 dBμV (+7 to +27 dBm), can be considered good. Note that because dynamic range — by definition — depends on the noise floor level, it will increase as bandwidth is reduced. Intercept point is sometimes specified (as are other parameters) in dBm, where a dBm is a dB relative to 1 mW into the system impedance (usually 50 ohms). 0 dBm (50 ohms) equals 224 mV PD (Potential Difference), or 113 dBμV, thus to convert from dBμV to dBm (50 ohms) simply subtract 113. (E.g., *0 dBμV = 1 μV EMF = 0.5 μV PD is −113 dBm).* Note: dBμV is dB relative 1 μV EMF.

*Readers are urged to consider the outstanding intermod performance achieved by using FETs these days. **Editor**

SAY YOU SAW IT IN HAM RADIO

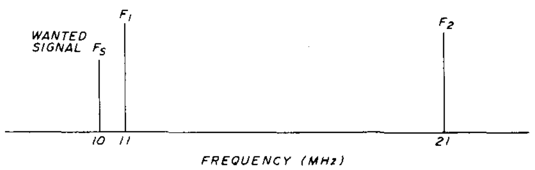


fig. 5. Example of second-order IMDs.

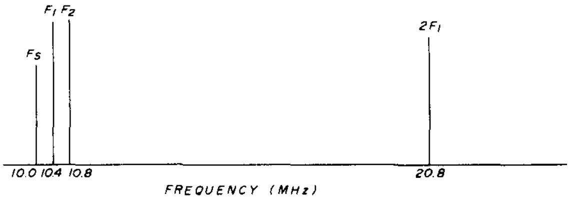


fig. 6. Example of third-order IMDs where $2F_1$ beats with F_2 to produce a response at 10.0 MHz.

intermodulation

Intermodulation product distortion (IMD) occurs when two large unwanted signals beat together (inter-modulate) in a non-linear receiver stage, to produce a product at the *wanted* frequency.

Second order intermodulation products equate to $F_1 \pm F_2$ (where F_1 and F_2 are the two unwanted frequencies). This process is shown in **fig. 5** where the two unwanted signals are at 11 and 21 MHz causing a beat at 10 MHz. (Signals at 6 and 16 MHz or 3 and 7 MHz would produce a similar product.)

One point to note about second order IMDs is that at least one of the unwanted signals must be outside the passband of any octave filter response that includes F_S and consequently can be rejected by any reasonably tight RF tuning, such as a good octave filter or sub-octave (less than an octave) filter.

Third-order intermodulation products are equal in frequency to $F_1 \pm 2F_2$. Thus both signals can be very close to the wanted signal, and well within the RF passband regardless of the type of RF tuning in use. This is seen in **fig. 6** where signals at 10.4 and 10.8 MHz produce a third-order IMD product of 10 MHz.

Intermodulation performance is typically specified as the levels of two unwanted signals not less than 20 kHz off tune (off the main signal frequency) to give a 0 dBμV (1 μV EMF) response. A good receiver will have a third-order IMD performance of 70 to 90 dBμV. A statistical analysis based on data relating to actual signals received over the whole of the HF band on wideband (rhombic) antennas[1,2] indicates that at least 90 dB is required. As specified above, this corresponds to a dynamic range of 100 dB and an intercept point of 134 dBμV or +21 dBm (50 ohms), as shown in **fig. 7**. It is easy to see why such a figure is needed. 90 dBμV corresponds to 32 mV EMF and at almost any time there will be tens of broadcast (and other) stations putting between 10 and 100 mV onto a wideband antenna, with hundreds of others in the range 1 to 10 mV (EMF)!

Second-order IMD performance, often not stated, can sometimes be misleading. Second-order performance can be poor enough to present a real problem even with good third-order performance if a wideband antenna is used without an antenna tuning unit (ATU). This is due to the use of unshielded octal filters of less than perfect performance. Levels similar to third-order performance are *required*.

In-band intermodulation occurs when two signals *within* the IF passband beat (mix) to produce extra products. It is normally of little significance in HF communications except where multichannel "Voice Frequency Telegraphy (VFT)" systems such as "Piccolo" are in use. A typical level of performance for a good receiver is for a product of −40 dB with reference to two in-bands signals.

Cross modulation occurs when modulation from an unwanted signal transfers itself across and "modulates" the wanted signal. Again this is due to non-linearities in the early receiver stages, and sometimes the same modulation will reappear on each adjacent signal tuned in. Cross modulation is a third-order effect, so good third-order IMD performance will tend to mean good cross modulation performance (see **fig. 8**).

Cross modulation may be specified as the level required in dBμV for a 30 percent modulated carrier greater than 20 kHz off channel to cause 3 percent cross modulation. A level of 70 to 90 dBμV is considered good.

Blocking, or de-sensitizing, is similar to cross modulation, but in this case the large off-channel signal causes a reduction in wanted signal output. It is specified as the signal required to reduce wanted output by 1 dB. It can often be caused by a strong CW signal, causing gain to go up and down with the keying. 90 to 110 dBμV is considered good performance, for a 1 mV (EMF) signal.

causes and cures of dynamic effects

Dynamic effects are caused by large off-channel signals driving the receiver into non-linearity. There are three fundamental methods of improving performance: (*a*) preventing the off-channel signals

a performance specification

This detailed specification indicates the performance required for a "very good" receiver. Additional parameters not mentioned previously, such as audio output power, have been added for completeness. Note that specifications like this should state worst-case figures (maximum or minimum values that are acceptable when the receiver is being tested); in some cases, however, "typical" values are used instead. This will at first sight make the receiver seem considerably better: for example, a worst-case NF of 10 dB will often (typically) be 7 dB. It is therefore important to establish whether a true specification or a list of typical values is meant. The specification below uses worst-case figures. Note dBμV is dB relative to 1 μV EMF.

specification

frequency coverage	**50 kHz to 30 MHz** (continuous coverage, using full synthesis)
frequency display	**7** digit, resolution 10 Hz
reception modes	CW, FSK (RTTY), SSB (USB and LSB), ISB, AM, NBFM
input impedance	**50** ohms
sensitivity (500 kHz to 30 MHz)	SSB, CW, ISB - 0.5 μV EMF for 10 dB SINAD in 3 kHz AM - 2.2 μV EMF for 10 dB SINAD in 8 kHz, modulation 30 percent FM - 0.8 μV EMF for 10 dB quieting in 15 kHz bandwidth, 60 percent deviation (Noise factor 10 dB)
IF selectivity	

filter	available on	response (kHz) −6 dB	−60 dB	shape factor
15 kHz	FM	15.00	33.00	2.2
8 kHz	AM	7.80	14.00	1.8
2.7 kHz	SSB, ISB, CW	2.70	4.30	1.6
1 kHz	CW	1.00	2.00	2.0
300 Hz	CW	0.28	0.75	2.7

dynamic range	**104 dB.** [Intercept point 140 dBμV = +27 dBm (50 ohms)] (3 kHz bandwidth).
third-order intermodulation	**94 dBμV.** The levels of two unwanted signals both greater than 20 kHz off frequency will be 94 dBμV [or −19 dBm (50 ohms)] to give a 1 μV (0 dBμV) response.
second-order intermodulation	**90 dBμV.** The levels of two unwanted signals both greater than 20 kHz off frequency will be 90 dBμV [−23 dBm (50 ohms)] to give a 1 μV (0 dBμV) response.
in-band intermodulation	**−40 dB.** Two signals in-band of equal amplitude will produce a product greater than 40 dB down.
cross modulation	**100 dBμV.** A 30 percent modulated carrier greater than 20 kHz off frequency must be 100 dBμV [−13 dBm (50 ohms)] to cause 3 percent cross modulation.
blocking	**100 dBμV.** A signal greater than 20 kHz off frequency will be 110 dBμV [−3 dBm (50 ohms)] to cause a 3 dB reduction of wanted 1 mV EMF (60 dBμV) signal.
reciprocal mixing	**90 dB.** An unwanted signal 50 kHz off frequency will be 90 dB above the level of a wanted on-frequency signal to reduce its SINAD by 3 dB, in a 3 kHz bandwidth.
image rejection	**90 dBμV.** The image frequency must be 90 dBμV [−23 dBm (50 ohms)] to give a 1 μV (0 dBμV) response.
IF rejection	**90 dBμV.** For the first and second IF the level of an unwanted signal will be 90 dBμV [−23 dBm (50 ohms)] to give a 1 μV (0 dBμ) response.
crosstalk	**−50 dB.** On ISB mode the crosstalk between two equal 0 dBm (600 ohm) outputs shall be less than −50 dB relative to output at 1 kHz.
response to internal spurii	All internally generated spurious signals are less than 3 dB above receiver noise. (3 kHz bandwidth.)
stability	After 10 minute warmup, better than 1 part in 10^8/°C. Long term crystal aging less than 1 part in 10^9 per day.
antenna radiation	Less than 10 μV_{PD} (20 μV EMF) into 50 ohms (−87 dBm). (2pW)
protection	Receiver can withstand 30 volts at antenna input continuously. A spark gap is provided.
AGC performance	For an input change of 90 dB, the output change will be less than 3 dB for all signal levels greater than 3 μV_{EMF} (10 dBμV).
AGC time constants	

	SLOW attack	SLOW hang	SLOW decay	FAST attack	FAST hang	FAST decay
ISB, SSB, CW	10 ms	2s	200 ms	5 ms	200 ms	50 ms
AM, FM	20 ms	—	20 ms	5 ms	—	5 ms

BFO range (CW)	±3 kHz
AF outputs	Main output: 2W into 8 ohms at less than 3 percent Total Harmonic Distortion (THD) Headphones: 20 mW into 600 ohms Line: 600 ohms balanced line independent of AF gain control, settable to −10 to +10 dBm (600 ohms), i.e. 245 mV to 2.5 VPD.
muting	0V on mute terminal for muting. Mute level at least 60 dB down.
metering	Meter reads signal strength in dBμV or AF line level in dBm (600 ohms).
power requirements	200 to 250 VAC, 45 to 65 Hz, at 50 VA (Volt-Amperes)
environment	Operating: 14 to 104°F (−10 to +40°C) Storage: −40 to 158°F (−40 to +70°C) Relative humidity up to 95 percent at 104°F (40°C) (non-condensing).
MTBF (mean time between failure)	8000 hours

from entering; (*b*) improving the linearity of the early stages of the receiver, prior to and including the roofing filter (a roofing filter is inserted in the first IF and is used to reduce the number of strong signals passing through the IF [chain]; it is not as narrow as the main selective filters); and (*c*) reducing the level of all signals.

This last method works because the response to the unwanted (dynamic) signals falls off at a faster rate than that of the wanted signals (see **fig. 4**). It is implemented by means of a front-end attenuator or by a wideband AGC loop (separate from the main AGC loop) which operates on the RF amplifier on large signals only, and thus can be thought of as being an automatic attenuator. Both methods have the disadvantage of reducing receiver sensitivity, and consequently other solutions should be found.

Method *(a)* involves the use of sub-octave filters or some sort of preselector tuning and can be very effective in reducing second order effects. However, as previously mentioned, third order products can be too close (in the signal passband) for tuned circuits to have an effect.

The only real solution is to improve linearity, (*b*). Bipolar transistors are particularly poor in this respect, but FETs are approximately square-law devices and are therefore very good in terms of third-order effects, but not as good for handling second-order products. Linearity can be improved by using higher power supply voltages and by keeping pre-roofing filter gain down to a minimum consistent with required sensitivity, and therefore by keeping noise levels down. In the extreme situation, the RF amplifier can be completely eliminated and the signals fed directly to a low-noise mixer via the front-end filters. This isn't such a drastic step as it might appear, because remember an NF of 15 dB is more than adequate on HF, and this can be achieved without an RF amplifier.

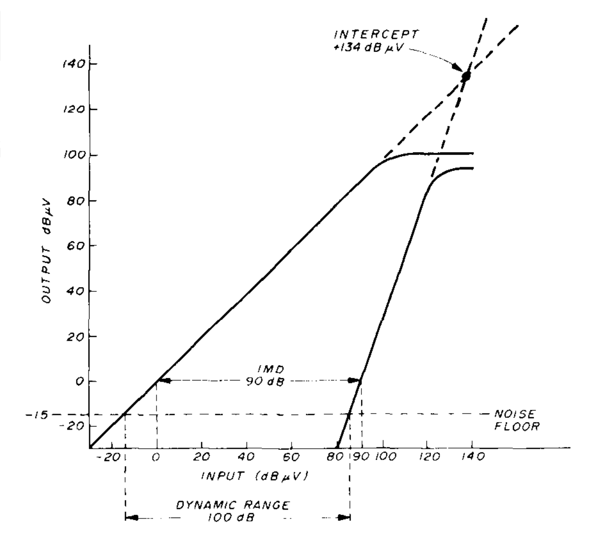


fig. 7. Good receiver third-order intermodulation distortion performance is shown as a 100 dB spurious-free dynamic range.

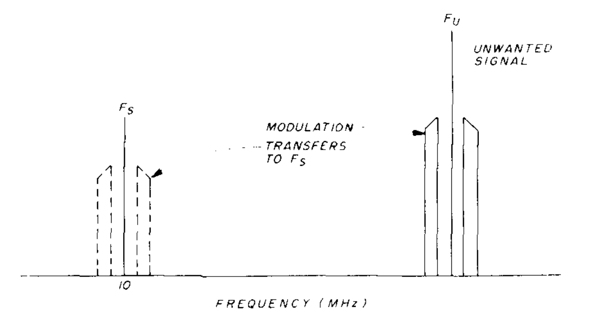


fig. 8. Cross modulation occurs when modulation from an "unwanted" signal transfers itself across and modulates the wanted signal.

The mixer may be a double-balanced switching type diode mixer using high level LO injection to improve linearity. Components normally considered to be linear, passive, and reciprocal must be carefully checked to ensure that they are. This especially applies to ferrite cores used for RF coils and transformers; and crystal filters, which are often non-linear and non-reciprocal, i.e. having different characteristics if connected the "wrong" way around.

The practice of fitting protection diodes at the receiver input (often found on marine-band receivers) will also cause non-linearity, as will diodes used to switch filters. If all these points are carefully considered, very good linearity can be achieved with an intercept point of 140 dBμV or better. This level of performance ensures that IMD cross-modulation products are below atmospheric noise on HF.

Reciprocal mixing is due to high level unwanted signals mixing with the noise sidebands of the local oscillator/synthesizer, producing noise products at the receive frequency (see **fig. 9**).

It is another phenomenon which until recently has been more or less ignored, partly because tube local oscillators are inherently "cleaner" than most of the modern solid-state synthesizers. It can be specified as the level in dB above a wanted signal that an unwanted signal can attain at a specified frequency off-channel (e.g. 50 kHz) at a specified bandwidth (usually 3 kHz) to reduce the S/N ratio of a wanted on-channel signal by 3 dB!

The oscillator noise can be reduced by employing high "Q" (oscillator) circuits, and also by using high power oscillators, as the noise sidebands will then be relatively weaker, thus improving S/N. Phase locked loops can be very poor in this respect because they contain numerous noise sources which add together in the output, together with frequency jitter. In addition, PLL's frequently use low "Q" circuits and low power VCOs in the output. The noise produced is phase modulated and cannot be removed by limiting.

The action of reciprocal mixing in introducing off-channel signals into the IF at levels proportional to the distance away from the wanted signal (frequency separation) (see **fig. 9**) effectively reduces the selectivity of the receiver. This is shown in **fig. 10**, and the response curves indicate the dynamic selectivity of the receiver, that is, the selectivity of the receiver in a real signal environment. As can be seen, it's the stopband of the filter response that's been changed; with 70 dB reciprocal mixing, a considerable loss of performance occurs.

However, when the reciprocal mixing has been improved to 90 dB, its effect on filter response can be considered fairly minor. A frequency-synthesized receiver can achieve 90 dB, while a good (tube or FET) crystal oscillator can give 110 dB or better.

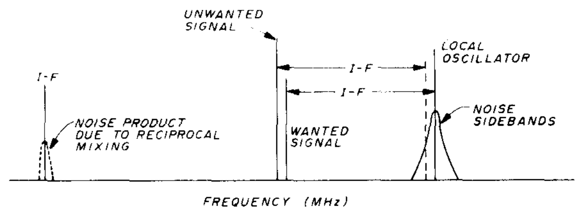


fig. 9. Reciprocal mixing reduces the useful dynamic range of the receiver.

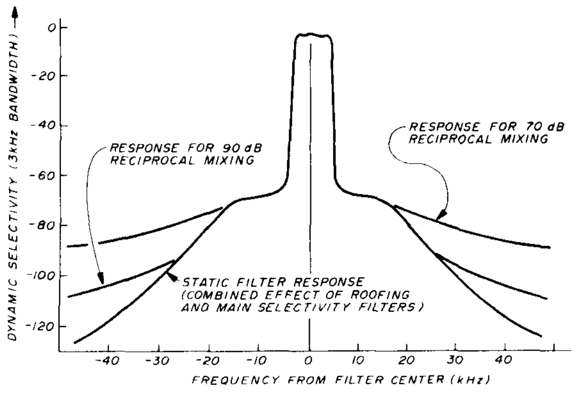


fig. 10. Dynamic selectivity differs from the static filter response because of reciprocal mixing.

synthesizer noise and internal spurious responses

Internal spurious responses are responses of the receiver to signals generated within the receiver itself. These internally generated signals can be fixed (e.g., reference frequencies) or can move when the receiver tuning is changed. They cause problems when they occur at the signal frequency or an IF, and are generated by any oscillators within the receiver or by digital circuitry such as synthesizers and frequency counters. (A current trend is to use multiplexed fluorescent displays instead of DC driven LED displays, which generate low frequency interference. Adequate shielding must be employed to reduce radiation.) In using frequency synthesis techniques, many of the waveforms are digital, square waves with fast rise-times rich in harmonics. CMOS and LSI (N-MOS) is usually better in this respect than TTL which has faster rise times. Careful design, with adequate low-pass and bandpass filtering and with high "Q" output circuits, is important. With good design it is possible to keep spurious outputs 100 dB down on the main output level. This standard of performance should ensure that all spurious responses are no more than 3 dB above the receiver noise level.

stability

A fully synthesized receiver can have a stability equal to that of the frequency reference source.[3] If an oven-temperature stabilized crystal oscillator is used, stability of less than 0.1 Hz/°C can be achieved. With partial synthesis the stability is governed by the stability of the VFO, but with cool, buffered solid-state designs it is possible to achieve long term drift rates of 100 Hz/hour with short term drift (even including lifting the receiver an inch and dropping it!) of 10 to 20 Hz. The latter is more than adequate for normal SSB/CW/RTTY/AM communications.

conclusions

The performance quality of the HF receiver has increased over the years and it is now possible to design a general coverage receiver that provides very high performance. As activity on the HF bands has constantly increased, this improvement in performance is of vital importance to maintain the ability to communicate.

Generally speaking, the cost of equipment has gone up in proportion to its complexity. There is, however, a reduction in real cost due, in part, to the availability of relatively low cost complex ICs, crystal filters, and FETs, as well as to improvements in design techniques.

Future trends will include more extensive use of

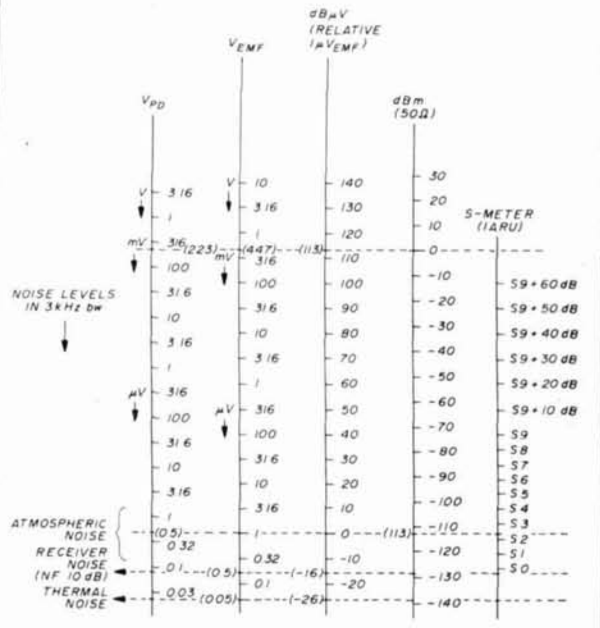


fig. 11. Voltage and power relationships.

ICs, with possibly a single chip full-synthesizer, and microprocessor control of the receiver. It seems likely that more extensive use will be made of remote control of receivers via data link, and that in communications centers a central mini-computer will be linked to each operating position, performing a variety of useful functions. On the domestic scene, the home computer can be linked to the receiver via an RS232 line, and can be used to decode RTTY and SSTV signals, etc. It could also be used as a big "memory" to store channels (frequencies/modes/filters and a channel ident) for instant recall.

In conclusion, receivers available now offer performance that ten years ago could be obtained only from professional receivers costing ten times as much, and which twenty years ago could not be obtained at all.

appendix

Fig. 11 shows the relationships between levels as specified in V(EMF), V(PD), dBμV, and dBm (50 ohms). Also shown is the S-meter response as recommended by the IARU, the International Amateur Radio Union. This specifies that S9 should be at 50 μV PD, or 100 μV EMF; and that each S-point should be at 6 dB intervals. Also shown are the thermal noise threshold and typical receiver and atmospheric noise terms for a 3 kHz bandwidth.

references

1. R.F.E. Winn, "Synthesized Communications Receiver," *Wireless World*, October, 1974, pages 413-417.

2. R.F.E. Winn, "Effects of Receiver Design in Communications Systems," *IERE Proceedings of the Conference on Radio Receivers and Associated Systems, 4-6*, July 1972, pages 193-204.

3. J.A. Dyer, "High Frequency Receiver Design," *Radio & Electronics World*, February, 1983, pages 48-53.

ham radio

RAMSEY ELECTRONIC'S Inc.

PARTS WAREHOUSE

We now have available a bunch of goodies too good to bypass. Items are limited so order today

2575 Baird Rd.
Penfield, NY 14526
716-586-3950

Call your Phone Order in Today. TERMS: Satisfaction guaranteed or money refunded. C.O.D. add $2.50. Minimum order $6.00. Orders under $10.00 add $1.50. Add 6% for postage, insurance, handling. Overseas add 15%. N.Y. residents add 7% tax.

MINI KITS - YOU HAVE SEEN THESE BEFORE NOW HERE ARE OLD FAVORITES AND NEW ONES TOO. GREAT FOR THAT AFTERNOON HOBBY.

FM MINI MIKE

A super high performance FM wireless mike kit! Transmits a stable signal up to 300 yards with exceptional audio quality by means of its built in electret mike. Kit includes case, mike, on-off switch, antenna, battery and super instructions. This is the finest unit available.

FM-3 Kit	$14.95
FM-3 Wired and Tested	$22.95

Color Organ

See music come alive! 3 different lights flicker with music. One light each for high, mid-range and lows. Each individually adjustable and drives up to 300 W. runs on 110 VAC.

Complete kit, ML-1
$8.95

Video Modulator Kit

Converts any TV to video monitor. Super stable, tunable over ch. 4-6. Runs on 5-15V, accepts std. video signal. Best unit on the market! Complete kit, VD-1 **$7.95**

Led Blinky Kit

A great attention getter which alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights, anything! Runs on 3 to 15 volts.
Complete kit, BL-1
$2.95

Super Sleuth

A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2 W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.
Complete kit, BN-9 **$5.95**

CPO-1

Runs on 3-12 Vdc 1 watt out, 1 KHZ good for CPO, Alarm, Audio Oscillator. Complete kit **$2.95**

CLOCK KITS

Your old favorites are here again. Over 7,000 Sold to Date. Be one of the gang and order yours today!

Try your hand at building the finest looking clock on the market. Its satin finish anodized aluminum case looks great anywhere, while six .4" LED digits provide a highly readable display. This is a complete kit, no extras needed, and it only takes 1-2 hours to assemble. Your choice of case colors: silver, gold, black (specify).

Clock kit, 12/24 hour, DC-5	**$24.95**
Clock with 10 min. ID timer, 12/24 hour, DC-10	**$29.95**

For wired and tested clocks add $10.00 to kit price.
SPECIFY 12 OR 24 HOUR FORMAT

FM Wireless Mike Kit

Transmits up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.

FM-1 kit **$3.95** FM-2 kit **$4.95**

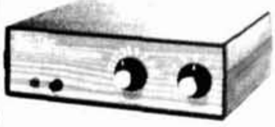
Whisper Light Kit

An interesting kit, small mike picks up sounds and converts them to light. The louder the sound, the brighter the light. Includes mike, controls up to 300 W, runs on 110 VAC.
Complete kit, WL-1
$6.95

Tone Decoder

A complete tone decoder on a single PC board. Features: 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts.
Complete kit, TD-1 **$5.95**

SATELLITE TV KIT



THE POPULAR SAT-TEC RECEIVER IN KIT-FORM!

NEW, LOWER PRICES!

Featured in a Radio Electronics magazine cover story (May 82), the reliable R2B Sat-tec TV receiver is now operating in thousands of locations. The R2B is easy to build; pre-etched, plated boards with screened co[...] layout assures accurate com[...] pla[...] and the critical IF sec[...] lo[...] osc[...] are pre-assembled a[...] [...]ed! [...] are included for the R2B, a[...] case, power supply, descriptive op[...]g manual as well as complete assembly instructions. Features of the receiver include: dual conversion design for best image rejection, fully tunable audio to recover 'hidden' subcarriers, divide by two PLL demodulator for excellent threshold performance, tight tracking AFC to assure drift free reception, and of course, full 24 channel tunable coverage.

Build your satellite TV system around the R2B, close to ten thousand others already have and now it's available in kit form at a new low price. Order yours today.

SOLD OUT

A [...]te Satellite TV System requires a [...]sh antenna, LNA (low noise amplifie[...]), Receiver and Modulator.

R2[...] Receiver Kit	$295.00
R2B Receiver, Wired and Tested	$395.00
120° K LNA	$295.00
RM3 RF Modulator	$49.95

Prices include domestic UPS shipping and insurance.

Universal Timer Kit

Provides the basic parts and PC board required to provide a source of precision timing and pulse generation. Uses 555 timer IC and includes a range of parts for most timing needs.

UT-5 Kit **$5.95**

Mad Blaster Kit

Produces LOUD ear shattering and attention getting siren like sound. Can supply up to 15 watts of obnoxious audio. Runs on 6-15 VDC

MB-1 Kit **$4.95**

Siren Kit

Produces upward and downward wail characteristic of a police siren. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.
Complete kit, SM-3 **$2.95**

60 Hz Time Base

Runs on 5-15 VDC. Low current (2.5ma) 1 min./month accuracy. TB-7 Kit **$5.50**
TB-7 Assy **$9.95**

PARTS PARADE

IC SPECIALS

LINEAR

301	$ .35
324	$1.50
380	$1.50
555	$ .45
556	$1.00
565	$1.00
566	$1.00
567	$1.25
741	10/$2.00
1458	$ .50
3900	$ .50
3914	$2.95
8038	$2.95

TTL

74S00	$ .40
7447	$ .65
7475	$ .50
7490	$ .50
74196	$1.35

SPECIAL

11C90	$15.00
10116	$ 1.25
7208	$17.50
7207A	$ 5.50
7216D	$21.00
7107C	$12.50
5314	$ 2.95
5375AB/G	$ 2.95
7001	$ 6.50

CMOS

4011	.50
4013	.50
4046	$1.85
4049	.50
4059	$9.00
4511	$2.00
4518	$1.35
5639	$1.75

FERRITE BEADS

With info and specs	15/$1.00
6 Hole Balun Beads	5/$1.00

READOUTS

FND 359 .4" C.C.	$1.00
FND 507/510 .5" C.A.	1.00
MAN 72/HP7730 .33" C.A.	1.00
HP 7651 .43" C.A.	2.00

Sockets

8 Pin	10/$2.00
14 Pin	10/$2.00
16 Pin	10/$2.00
24 Pin	4/$2.00
28 Pin	4/$2.00
40 Pin	3/$2.00

TRANSISTORS

2N3904 NPN C+F	15/$1.00
2N3906 PNP C+F	15/$1.00
2N4403 PNP C+F	15/$1.00
2N4410 NPN C+F	15/$1.00
2N4916 FET C+F	4/$1.00
2N5401 PNP C+F	5/$1.00
2N6028 C+F	4/$1.00
2N3771 NPN Silicon	$1.50
2N5179 UHF NPN	3/$2.00
Power Tab NPN 40W	3/$1.00
Power Tab PNP 40W	3/1.00
MPF 102/2N5484	$.50
NPN 3904 Type T+R	50/$2.50
PNP 3906 Type T+R	50/$2.50
2N3055	$.80
2N2646 UJT	3/$2.00

Diodes

5.1 V Zener	20/$1.00
1N914 Type	50/$1.00
1KV 2Amp	8/$1.00
100V 1Amp	15/$1.00

25 AMP
100V Bridge
$1.50 each

Mini-Bridge 50V
1 AMP
2 for $1.00

Resistor Ass't

Assortment of Popular values - ¼ watt. Cut lead for PC mounting ½" center ¼" leads, bag of 300 or more **$1.50**

Crystals

3.579545 MHZ	$1.50
10.00000 MHZ	$5.00
5.248800 MHZ	$5.00

Switches

Mini toggle SPDT	$1.00
Red Pushbuttons N.O.	3/$1.00

AC Adapters

Good for clocks, nicad chargers, all 110 VAC plug one end

8.5 vdc @ 20 mA	$1.00
16 vac @ 160mA	$2.50
12 vac @ 250mA	$3.00

Earphones

3" leads, 8 ohm, good for small tone speakers, alarm clocks, etc.
5 for $1.00

Mini 8 ohm Speaker

Approx. 2¼" diam. Round type for radios, mike etc.
3 for $2.00

Solid State Buzzers

small buzzer 450 Hz 86 dB sound output on 5-12 vdc at 10-30 mA. TTL compatible **$1.50**

Slug Tuned Coils

Small 3/16" Hex Slugs turned coil 3 turns 10 for $1.00

AC Outlet

Panel Mount with Leads
4/$1.00

CAPACITORS

TANTALUM Dipped Epoxy		ALUMINUM Electrolytic		DISK CERAMIC	
1.5 uF 25V	3/$1.00	1000 uF 16V Radial	$.50	.01 16V disk	20/$1.00
1.8 uF 25V	3/$1.00	500 uF 20V Axial	$.50	.1 16V	15/$1.00
.22 uF 25V	3/$1.00	150 uF 16V Axial	5/$1.00	.001 16V	20/$1.00
		10 uF 15V Radial	10/$1.00	100 pF	20/$1.00
				.047 16V	20/$1.00

DC-DC Converter

+5 vdc input prod. -9 vdc @ 30ma
+9 vdc produces -15 vdc @ 35ma **$1.25**

Ceramic IF Filters

Mini [...] kHz
B.W. [...] $1.50 ea.
SOLD OUT

25K 20 Turn Trim Pot	$1.00
1K 20 Turn Trim Pot	$ .50

Trimmer Caps

Sprague - 3-40 pf
Stable Polypropylene
.50 ea.

Crystal Microphone

Small 1" diameter ¼" thick crystal mike cartridge **$.75**

Mini RG-174 Coax
10 ft. for $1.00

Coax Connector

Chassis mount
BNC type **$1.00**

9 Volt Battery Clips

Nice quality clips	5 for $1.00
⅜" Rubber Grommets	10 for $1.00

Parts Bag

Asst. of chokes, disc caps, tant., resistors, transistors, diodes, MICA caps etc.
sm. bag (100 pc) **$1.00** lg. bag (300 pc) **$2.50**

Connectors

6 pin type gold contacts for mA-1003 car clock module
price **.75 ea.**

Leds - your choice, please specify

Mini Red, Jumbo Red, High Intensity Red, Illuminator Red	8/$1
Mini Yellow, Jumbo Yellow, Jumbo Green	6/$1

Varactors

Motorola MV 2209 30 PF Nominal cap 20-80 PF - Tunable range -
.50 each or 3/$1.00

Audio Prescaler

Make high resolution audio measurments, great for musical instrument tuning, PL tones, etc. Multiplies audio UP in frequency, selectable x10 or x100, gives .01 HZ resolution with 1 sec. gate time! High sensitivity of 25 mv, 1 meg input z and built-in filtering gives great performance. Runs on 9V battery, all CMOS.

PS-2 kit	$39.95
PS-2 wired	$49.95

600 MHz PRESCALER

Extend the range of your counter to 600 MHz. Works with all counters. Less than 150 mv sensitivity, specify -10 or -100

Wired, tested, PS-1B	**$59.95**
Kit, PS-1B	**$44.95**

30 Watt 2 mtr PWR AMP

Simple Class C power amp features 8 times power gain. 1 W in for 8 out, 2 W in for 15 out, 4W in for 30 out. Max output of 35 W, incredible value, complete with all parts, less case and T-R relay.

PA-1, 30 W pwr amp kit	**$24.95**
TR-1, RF sensed T-R relay kit	**$6.95**

MRF-238 transistor as used in PA-1
8-10db gain 150 mhz **$11.95**

RF actuated relay senses RF (1W) and closes DPDT relay. For RF sensed T-R relay
TR-1 Kit **$6.95**

Power Supply Kit

Complete triple regulated power supply provides variable 6 to 18 volts at 200 ma and +5 at 1 Amp. Excellent load regulation, good filtering and small size. Less transformers, requires 6.3 V @ 1 A and 24 VCT.
Complete kit PS-3LT **$6.95**

OP-AMP Special

BI-FET LF 13741 - Direct pin for pin 741 co[...] but 500,000 MEG input z, super low 50 pa input curr[...] power drain
50 for only $9.00 **10 for $2.00**
SOLD OUT

Regulators

78MG	$1.25	7812	$1.00
79MG	$1.25	7815	$1.00
723	$.50	7905	$1.25
309K	$1.15	7912	$1.25
7805	$1.00	7915	$1.25

Shrink Tubing Nubs

Nice precut pces of shrink size 1" x ¼" shrink to ⅛". Great for splices **50/$1.00**

Mini TO-92 Heat Sinks

Thermalloy Brand	5 for $1.00
To-220 Heat Sinks	3 for $1.00

Opto Isolators - 4N28 type	**$.50 ea.**
Opto Reflectors - Photo diode + LED	**$1.00 ea.**

Molex Pins

Molex already precut in length of 7. Perfect for 14 pin sockets. **20 strips for $1.00**

CDS Photocells

Resistance varies with light. 250 ohms to over 3 meg **3 for $1.00**

✓ 176

More Details? CHECK—OFF Page 108

Joe Reisert W1JR

VHF/UHF antennas and antenna systems

There is probably no other VHF/UHF topic that inspires such a vigorous line of conversation than the subject of antennas. Hardly a day goes by when I'm not asked questions like "What type of antenna do you recommend?" or "What's the difference between this antenna and that one?" The reason we're so interested in this subject is that there is no better way to improve the performance of your station: *a 1 dB improvement in antenna gain yields a 2 dB overall increase in your station capability,* since we gain 1 dB on transmit and 1 dB on receive.

The answers to the questions above are neither simple nor obvious; they take time to answer thoroughly. Furthermore, the answers may not always involve performance as much as economic or structural considerations. With this in mind, I've decided to discuss the popular types of VHF/UHF antennas and the tradeoffs between them in this month's column. Future columns will zero in on ways to measure and obtain peak performance with the antennas we are using.

antenna types

The three major types of VHF/UHF antennas presently in use (excluding FM/repeater types) are the collinear array, the Yagi and the parabolic dish. Each type has its own advantages and disadvantages. While all can produce high gain, they differ vastly in form factor. Let's discuss each type individually and see what each can and can't do.

collinear array

The collinear array was very popular among VHF/UHF'ers and especially EME'ers (Earth-Moon-Earth) on 2 meters and 70 cm (432 MHz) before high performance VHF/UHF Yagi antennas were designed. It usually consists of a group of half-wavelength dipoles in front of a screen or set of reflectors (**fig. 1**). Technically speaking, you could probably call this an array of 2-element Yagi antennas. Some individuals have even placed additional directors in front of the driven dipoles in an attempt to increase gain.[1] The unique thing about a collinear array is that the feed system is usually some form of open wire line. The collinear, unlike many antennas, is usually quite broadband. Efficiency can be very high and gain is mainly a function of the size of the array. The extended-expanded collinear is a stretched-out version that has fewer elements and higher gain approaching 80 to 95 percent efficiency.[2] This antenna is treated in depth in reference 2 and improvements are mentioned in reference 3.

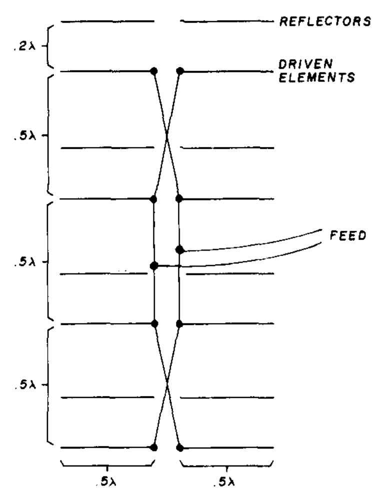


fig. 1. Typical collinear array.

Collinear antennas offer several advantages: They are not "critical" to build, are usually low in cost, have a low loss feed system, and when used on EME, can be readily adapted to polarity rotation. They are also easy to array when extremely high gain is desired. The principal drawback is their overall size, which usually precludes mounting other antennas on the same mast. (I'll discuss this subject later in this column.) There may also be problems in areas where moisture is present, since the VSWR may increase if the feed system gets damp or wet.

Yagi and Yagi type antennas

The Yagi antenna (**fig. 2**) is particularly popular where space is at a premium or when only narrowband operation is required. It is presently the workhorse in the VHF and lower UHF spectrum. The first high gain VHF Yagi designs were published by Kmosko and Johnson,[4] Greenblum,[5] and Ehrenspeck and Poehler.[6] Unfortunately, these Yagis weren't always as good as claimed, were hard to duplicate, and when duplicated, often failed to deliver the promised gain. Some had very high side lobes.

The WØEYE 70 cm 4.2 wavelength 15 element Yagi[7] with corrections[8] was first published in 1972. Based on the unpublished work of Pete Viezbicke at NBS (National Bureau of Standards), it was the first really high gain Yagi with a clean pattern that was easily duplicated. Don Hilliard, WØEYE (now WØPW), and I urged Pete to publish his work and he finally did so in December, 1977, in *NBS Technical Note 688*, now out of print.[9] This publication, the result of extensive studies done by NBS in the 1950's to develop high gain arrays for ionospheric scatter, included six different models with boomlengths of 0.4 to 4.2 wavelengths. In the August, 1977 issue of *ham radio*, I published an article which included the

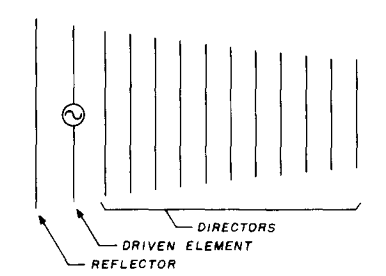


fig. 2. Typical long-Yagi.

majority of the NBS material along with several practical examples of Yagi designs using this material.[10] (A future column will deal with this topic in greater detail.)

The NBS Yagi designs described above work well through 70 cm, but the longest one is only 4.2 wavelengths (approximately 10 feet or 3 meters at 70 cm). Günter Hoch, DL6WU, has been working on this problem and has recently produced some very long Yagis[11] based on an extension of the work of Greenblum.[5] Hoch has been able to increase the gain approximately 2.35 dB each time the boomlength is doubled and has demonstrated this success even at 23 cm (1296 MHz). I have verified his information with a 70 cm 9.25 wavelength (21 feet or 6.5 meters) model which measured greater than 17.5 dB over a dipole gain at the 1981 Central States VHF Conference.[12] At the 1983 Central States VHF Conference, KL7WE entered an even longer (24 feet or 7.5 meter) 70 cm Yagi model based on the same information and it measured approximately 18 dB over a dipole. Hence the quest for extremely high gain Yagis is finally showing promise.

the Quagi

In April 1977 Wayne Overbeck, K6YNB/N6NB, published a description of an antenna he called the "Quagi."[13] This antenna is basically a Yagi with a cubical quad-type reflector and driven element. The design shown was low in cost, used a wooden boom, and was fed directly with coax. Newer designs have been published;[14] DL9KR and others have further optimized this design and modified the feed systems for use in large (groups of 16) EME arrays. This design could probably still use some optimization; only a few specific designs are available.

the log-periodic antenna array

The log-periodic antenna array,[15] a series of elements resembling a Yagi antenna, but with all elements fed by a special feed system, has never gained much acceptance among VHF/UHF'ers (except ATV'ers) because it is basically a wideband (multi-octave) structure with only moderate gain. The late Oliver Swan developed a hybrid antenna called the log-periodic Yagi, which has somewhat wider bandwidth than the typical Yagi.[16] It uses a log-periodic feed system to excite the directors of a Yagi structure. A 70 cm log-periodic Yagi has also been published.[17]

loop Yagis

Until recently, very few Yagi designs were used on the 23 cm band because they were hard to duplicate and extremely tight tolerances were required. The boom-to-element attachment had been a problem both electrically and mechanically, which further aggravated the tolerance problem.

In 1974, Mike Walters, G3JVL, decided to take a different approach to the Yagi antenna. At first he experimented with cubical quad loops made of wire, but could not obtain the desired performance. He then changed the elements to thin 0.028 inch (0.7 mm) aluminum straps 3/16 inch (4.7 mm) wide bent in a circle. After much trial and error, he developed a 23 cm, 28 element high gain "loop Yagi."[18] Later he developed longer models and also a table of corrections for different boom and element sizes.[19] The use of a round boom with his unique element-to-boom mounting method and the correction tables has been one of the reasons this design has been so successful. This antenna has been used as low as 70 cm and as high as 3 cm (10.256 GHz). A 45-element W1JR-designed loop Yagi had greater than 19 dB gain over a dipole as measured at the 1983 Eastern VHF/UHF Conference.

stacking

When really high gain is desired (such as in EME), Yagi antennas can be either arrayed or stacked. Generally speaking, every time you double the number of Yagi antennas in an array, you can increase the gain approximately 2.5 dB *if the proper stacking distance is used and the feedline loss is kept low* (this will be covered in a later column). Recent work on 70 cm EME tends to confirm that the best compromise is to use the highest gain Yagi design possible. Then the number of Yagis in the array will be at a minimum, and feedline problems will be more manageable. For general terrestrial operation, it is usually desirable to stack antennas vertically so that the beamwidth in the azimuth plane will stay wide and thereby spare you severe rotator aiming problems. This is particularly desirable for meteor scatter communication, in which the field of reflection can be wide.

parabolic dish antennas

The parabolic dish (**fig. 3**) is still one of the favorite antennas on 23 cm and above — especially on EME. The gain of this type of antenna is primarily determined by its size (diameter), providing that the feed or illuminator is properly chosen. There are many advantages to using this type of antenna. It is frequency-independent, meaning that you can change frequency by simply replacing the feed

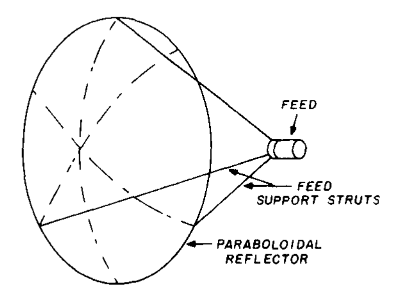


fig. 3. Typical parabolic dish (TNX W2IMU).

system with one for the proper frequency. A properly built parabolic dish antenna system will also be quieter on receiving because side and rear lobes are lower than most other antenna systems. Its principal disadvantages are that efficiency is low (typically 50 to 55 percent, even if everything is done right) and high wind resistance. (Recommended feed systems for parabolic dishes are described further in reference 3.)

conclusion

Hopefully the above information and the additional articles referenced will make it easier for you to determine which antenna type is best for you. The collinears are usually low in cost and easy to build, but if high gain is desired, they must be large. Where multiple band capability is desired on a single mast, the Yagi is hard to beat. When high gain on UHF and especially EME are sought, the parabolic dish offers many advantages; but again, if high gain is desired, the antenna system must be large. While we've discussed many types of antennas for VHF/UHF, we haven't discussed them in great detail. We'll deal with each type more comprehensively as time passes. But it will be up to you to weigh the advantages and disadvantages of each, make your decision, and take the plunge.

references

1. Bill Smith, W1DVE/KØCER, "The World Above 50 Mc," *QST*, March, 1967, pages 87-88.
2. Joseph H. Reisert, W6FZJ/1, "VHF Antenna Arrays for High Performance," *QST*, December, 1974, pages 38-44.
3. Joe Reisert, W1JR, "Requirements and Recommendations for 70 cm EME," *ham radio*, June, 1982, pages 12-19.
4. James A. Kmosko, W2NLY, and Hebert G. Johnson, W6QKI, *"Long* Long Yagis," *QST*, January, 1956, pages 19-24.
5. Carl Greenblum, "Notes on the Development of Yagi Arrays, Part I," *QST*, August, 1956, pages 11-17.
6. H.W. Ehrenspeck and H. Poehler, "A New Method for Obtaining Maximum Gain from Yagi Antennas," *IRE Transactions on Antennas and Propagation*," October, 1959, apges 379-386.
7. Bill Smith, KØCER, "The World Above 50 Mc," *QST*, January, 1972, pages 96-97.
8. Bill Smith, KØCER, "The World Above 50 Mc," *QST*, March, 1972, page 101.
9. Peter Viezbicke, "Yagi Antenna Design," *NBS Technical Note 688*, December, 1976.
10. Joseph H. Reisert, Jr., W1JR, "How to Design Yagi Antennas," *ham radio*, August, 1977, pages 22-31.
11. Günter Hoch, DL6WU, "Extremely Long Yagi Antennas," *VHF Communications*, March, 1982, pages 130-138.
12. Joseph H. Reisert, Jr., W1JR, "A High Gain Long Yagi for 70 CM," *The Lunar Letter*, June/July, 1983, pages 20, 21.
13. Wayne Overbeck, K6YNB, "The VHF Quagi," *QST*, April, 1977, pages 11-14.
14. Wayne Overbeck, K6YNB/N6NB, "The Long-Boom Quagi," *QST*, February, 1978, pages 20-21.
15. Carl Milner, W1FVY, "Log Periodic Antennas," *QST*, November, 1959, pages 11-14.
16. Del Crowell, K6RIL and William Orr, W6SAI, "Log Periodic Beam Antennas," *ham radio*, July, 1969, pages 8-13.
17. Ken Holladay, K6HCP, "High Gain Yagi for 432 MHz," *ham radio*, January, 1976, pages 46-47.
18. Dain Evans, G3RPE, "Microwaves," *Radio Communications*, January, 1975, pages 24-25.
19. Charles Suckling, G3WDG, "Microwaves," *Radio Communications*, September, 1978, pages 782-783.

VHF/UHF coming events:
Best EME Weekend: February 18-19

ham radio

Computer Books

NEW!

Commodore 64 and VIC-20

Commodore 64/VIC-20 Computer Programs for Beginners, by Howard Adler, three-dozen all-new programs practical for home, classroom, office, 96 pages, available October, ISBN 0-86668-033-0. **$8.95**

VIC-20 and Commodore 64 Computer Program Writing Workbook, by Howard Adler, useful collection of software-writing coding forms, graphics grids, BASIC instruction for VIC and Commodore 64, ISBN 0-86668-811-0. **$4.95**

101 Programming Tips & Tricks for the VIC-20 and Commodore 64, by Howard Adler, collection of practical efficient program-writing hints, secrets, techniques, shortcuts, easy-to-use instructions, includes 101 ready-to-run programs, 128 pages, ISBN 0-86668-030-6. **$8.95**

34 VIC-20 Computer Programs for Home, School & Office, by Howard Adler, tested ready-to-type-and-run software for classroom, business, home, all new for VIC, Commodore 64, 96 pages, ISBN 0-86668-029-2. **$8.95**

TRS-80 Color Computer

Color Computer Graphics, by Ron Clark, complete guide, loaded with instruction, how to make the most of video graphics, many complete programs, 128 pages, ISBN 0-86668-012-8. **$9.95**

101 Color Computer Programming Tips & Tricks, by Ron Clark, learn-by-doing instructions, hints, secrets, shortcuts, techniques, insights, includes 101 ready-to-run programs, 128 pages, ISBN 0-86668-007-1. **$7.95**

55 Color Computer Programs for Home, School & Office, by Ron Clark, practical ready-to-run software with colorful graphics, 128 pages, ISBN 0-86668-005-5. **$9.95**

55 MORE Color Computer Programs for Home, School & Office, by Ron Clark, handy companion volume packed with different useful type-and-run software, 112 pages, ISBN 0-86668-008-X. **$9.95**

Apple Computers

101 APPLE Computer Programming Tips & Tricks, by Fred White, secrets, hints, insights, learn-by-doing instruction, techniques, includes 101 ready-to-run programs, 128 pages, ISBN 0-86668-015-2. **$8.95**

33 New APPLE Computer Programs for Home, School & Office, by Fred White, practical ready-to-type-in-and-run software, 96 pages, ISBN 0-86668-016-0. **$8.95**

APPLE Computer Program Writing Workbook, by Fred White, 96 pages, 8 1/2x11, ISBN 0-86668-813-7. **$4.95**

Please add $2.00 for shipping and handling.

SEND TO: HAM RADIO'S BOOKSTORE
GREENVILLE, NH 03048
(603) 878-1441

MICROWAVE VIDEO RECEIVER

34+ dB GAIN • FREQUENCY 2.1 to 2.6 GHz
ABSOLUTELY WATERPROOF
COMPLETE • READY TO INSTALL
1 YEAR WARRANTY
$124.95 — INCLUDES:
TAX - SHIPPING - HANDLING

SEND CHECK - MONEY ORDER - OR CERTIFIED FUNDS TO:

K & S MICRO ELECTRONICS
1920 WEST GRANADA
PHOENIX, ARIZONA 85009

FOR LOWEST PRICES ON QUANTITY ORDERS CALL:
(602) 253-8605

INDIVIDUAL COMPONENTS AVAILABLE
FAST-EXPERT REPAIR ON ALL TYPES

✓ 155

Now you can own the Most Accurate Clock the easy Heathkit way!

The most accurate consumer clock ever made! The Heath GC-1000 Most Accurate Clock sets and corrects itself automatically by receiving shortwave broadcasts from the National Bureau of Standards. Microprocessor circuitry displays hours, minutes, seconds and even tenths of seconds. Kit priced at $249.95. Send for complete details today using the coupon below. Visa and MasterCard orders call TOLL-FREE: 1-800-253-0570.

Heathkit®
Heath
Company

FREE COLORFUL CATALOG

Please send me my FREE Heathkit Catalog featuring the GC-1000 Most Accurate Clock and many other quality electronic kits.

Name ______________________

Address ______________________ Apt. ______

City ______________________

State ______________ Zip ______________

MAIL TO: Heath Company, Dept. 122-141
CL-766 Benton Harbor, MI 49022

✓ 146

the
weekender

transmitter tuning aid: buffer your load with this resistive network

The temporary high SWR often encountered when tuning up your transmitter and tuning unit can often lead to disastrous consequences: abnormally high voltages and/or currents can easily damage expensive equipment, even in only a few seconds. If you once, perhaps, pit the variable capacitors of your final amplifier by an arc over, there is very little that can easily be done to repair the damage. In some cases, manufacturers have designed automatic circuitry that reduces power output when the SWR goes up, but this technique offers only limited protection rather than a basic solution.

With these concerns in mind, I developed and built a dummy load to overcome these problems. All discussions and calculations are based upon a 50-ohm impedance system, which is common to most of our modern transmitters and tuning systems. However, the equations can be used for any impedance system, or for any SWR limiting value desired.

The basic idea is to use a balanced-T resistive network, with a characteristic impedance of 50 ohms, to absorb most of the transmitter power during tune up, while still providing sufficient power to allow for proper tune up of your transmitter and antenna system. The isolation effect of the network is such that it limits your transmitter SWR to a maximum of 2:1, even if you were to short out or open the input to your tuning unit, which would be the worst condition that could develop.

Fig. 1 shows the basic circuit, along with theoretical calculated values of resistance, and wattage dissipation for a transmitter with an output of 100 watts. This figure was chosen for ease of calculation and presentation of the developed equations. Although the network is a balanced type, so that R_A is numerically equal to R_D in ohms, the different subscripts are shown to denote different wattage dissipation.

By William Vissers, K4KI, 1245 South Orlando Avenue, Cocoa Beach, Florida 39231

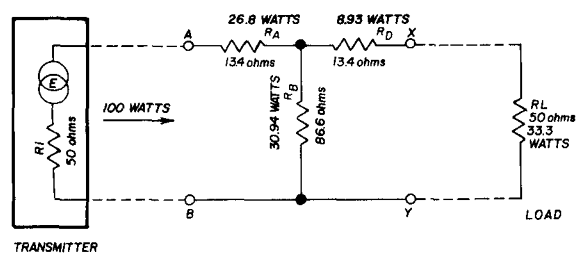


fig. 1. Balanced-T power-resistive network calculated values.

The equations relating the maximum value of SWR, which was chosen as 2:1, the characteristic impedance of the system R_C of 50 ohms, and the network resistance values are:

$$R_A + R_B = (R_C)(SWR) = (50)(2) = 100\ ohms$$

$$R_A + (R_D)(R_B)/(R_D + R_B) = R_C/SWR$$
$$= 50/2 = 25\ ohms$$

Having two equations and two unknowns, the network is solved using the basic quadratic equation, where:

$$R_A = R_D = 13.4\ ohms \text{ and } R_B = 86.6\ ohms$$

Again looking at **fig. 1**, if terminals X-Y are shorted out, the resistance looking in at points A-B is 25 ohms, so the transmitter SWR would be 50/25 = 2:1. If terminals X-Y are left open, the resistance looking into points A-B would be 100 ohms, and the transmitter SWR will once again be 100/50 = 2:1.

The characteristic impedance of the network is determined by these open and short circuit conditions where:

$$R_C = \sqrt{(R_{s.c.})(R_{o.c.})} = \sqrt{(100)(25)} = 50\ ohms$$

All of the original design requirements have been satisfied.

During actual tune up, R_L, the 50-ohm load resistance, is replaced by the input of the matching unit in the circuit in **fig. 2**.

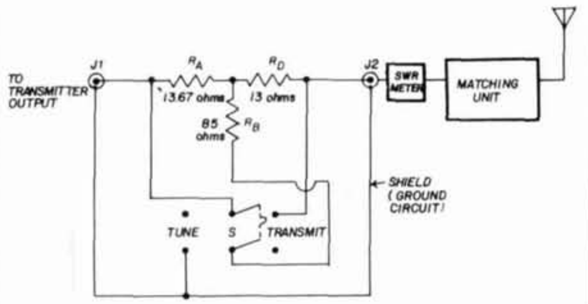
From **fig. 1**, it is seen that the power delivered to the load is 33-1/3 watts, or 1/3 of the transmitter output power of 100 watts at terminals A and B. This still provides plenty of power for tune up, yet offers an added advantage in that your "tune up QRM" has dropped by a factor of $(10)(log_{10})(1/3) = -4.77\ dB$. This reduction will be appreciated by other Amateurs on our already crowded bands.

A few years ago I experimented with building and using ordinary two-watt carbon resistors in parallel,

immersed in oil for a simple 50-ohm dummy load. I decided to follow the same procedure used then for the final T network, (**fig. 2**), in this project. My earlier tests had shown it was possible to use a heat dissipation factor of 2.5 as a conservative approach for normal tune-up time. To choose resistors, I checked to see what was available at my local electronics store, and then calculated what was needed to approach the theoretical values previously identified. For R_A, six 82-ohm, 2-watt carbon composition resistors in parallel equal 13.67 ohms with an allowable wattage rating of *(watts per resistor)(number of resistors) (derating factor)* = $(2)(6)(2.5) = 30$ *watts*, which was above the previously calculated value of 26.8 watts. (The values of resistors specified are shown in the parts list of **fig. 2**.)

Although the actual network resistance values differ slightly from the theoretically calculated values, actual tests showed the differences to be insignificant in operation. The network is very tolerant of small resistance deviations. This means you can simply use off-the-shelf items — there's no need to handpick resistance values.

There are other advantages in using the unit. Because your transmitter SWR during tune up can never go above 2:1 under the worst of conditions (and even then your reflected power is still only 11 percent of forward power), *your final amplifier output tuning control positions will be very close to their actual positions when you are finally tuned up to a perfect SWR of 1:1*. This makes tune up faster than it would be if you tried to tune up your amplifier while it was connected directly to your matching unit. Under the latter circumstances, the operation of tuner and transmitter controls is often so complex as to make one wish for four hands instead of two, and an extra pair of eyes to watch the SWR meter, lest it go much over 2:1.



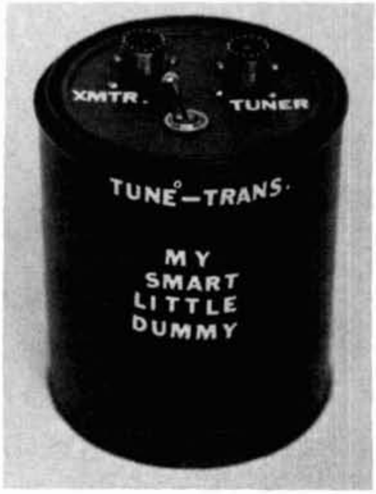
J1,J2	SO-239 coax connectors
R_A	82-ohm, 2 watt, carbon resistors — 5 percent tolerance (6 needed)
R_B	680-ohm, 2-watt, carbon resistors — 5 percent tolerance (8 needed)
R_D	39-ohm, 2-watt, carbon resistors — 5 percent tolerance (3 needed)
S	10 amp, 250 volt, DPDT toggle switch

1 quart paint can (empty)

1 quart transformer oil, mineral oil, or automobile transmission oil

Caution: Transformer oil of unknown origin may contain PCBs, a hazardous compound. See "PCBs in the ham shack," ham radio, December, 1983, page 42.

fig. 2. Completed balanced-T circuit values and placement in output line.



Completed balanced-T resistive network.

Another advantage of the unit is that you can switch it from TUNE to TRANSMIT when you are tuned up without having to turn off transmitter power, the circuit design prevents dangerous switching transients from occurring. Finally, because the unit is an in-line device, you will not need an expensive coax switch as might be necessary with a regular dummy load.

Although the design shown was for a balanced-T network, an equivalent Pi network with suitably calculated resistances and wattage values works just as well. The technique is also adaptable for high power. Actually, my first unit built was a converted home-brewed, flea market, 1 kW gallon-sized dummy which used a number of vitreous enameled non-inductive resistances, similar to the ones manufactured by Dale Electronics, Inc., P.O. Box 609, Columbus, Nebraska 68601. Although my copy of their catalog did not specify the highest frequency at which their non-inductive resistors could be used, my old restructured dummy, with similar resistances, worked fine down through 10 meters.

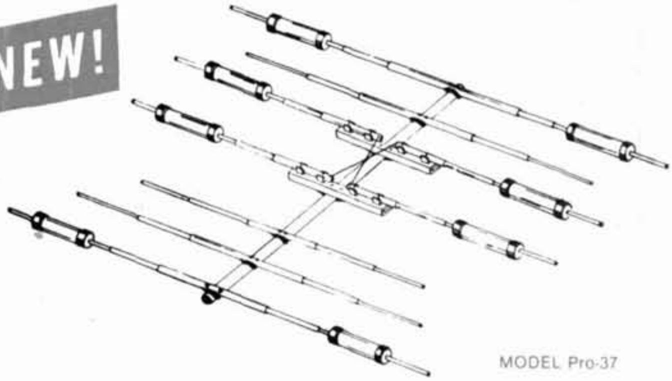
This device has also been thoroughly tested by Russ Forsyth, K4YS, under a variety of operating conditions. His helpful suggestions and comments are part of this article.

ham radio

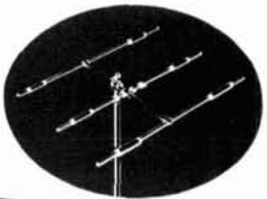
More Details? CHECK—OFF Page 108

OUTSTANDING PERFORMANCE with MOSLEY ANTENNAS

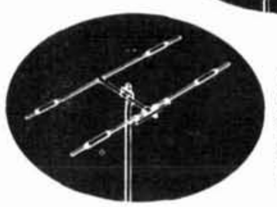
NEW!



MODEL Pro-37



TA-33 Jr.
Three element rotary beam aerial.
10-15-20M.
Rated to 300W.



Two element rotary beam aerial.
10-15-20M.
Rated to 300W.
MODEL TA-32 Jr.

The Pro-37 follows in the Mosley tradition of high performance, dependability, and quality construction. The Pro-37 is pre-drilled for easy assembly. No adjustments or measuring. Average assembly is about 1½ to 2 hours. As with all the Mosley antennas we use stainless steel hardware throughout. Rugged construction makes our antenna the cleanest, strongest of its class, no cluttered elements or boom to cause electrical and mechanical problems down the road. Put it up and leave it up. In performances it has no peers...It is as broadbanded or broaderbanded than any antenna made. Its gain and front to back is as good or better than other antennas in its class, even those with longer booms. Mechanically we feel it's the best built.

The Pro-37 has 7 elements on a 24 foot boom which needs no boom support. It has 3 wide spaced elements on 20 and 15 not counting the extra driven element. 10 meters has 4 wide spaced elements not counting the extra driven element. The Pro-37 uses a unique direct feed system which enables the driven elements to contribute gain to the antenna, while giving it the broadest possible frequency spectrum. Clean design makes the antenna easy to assemble and erect and solves maintenance problems. No clutter on the elements or boom. The Pro-37 uses the proven Mosley traps which on the Pro-37 will handle 2.5 KWDC out on C.W. and 5 KWPEP on SSB. We're quite excited about the Pro-37 and we know you will be too!

new!

Vertical Aerial, 10 thru 40 no bandswitching is necessary. Very portable and no pipe mount needed
MODEL V-4-6

V-4-6

Want 40 Meter DX?
Then Try...

S-401

BROADBANDED SINGLE ELEMENT
Can be made into 2 element or 3 element later.

MODEL CL-33

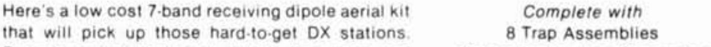
WANT A HIGH PERFORMANCE TRI-BANDER BUT SMALLER? THEN THE CL-33 IS FOR YOU!

- 3 elements on an 18' boom
- Wide spaced for gain higher than normal size TRI-Banders
- Uses our Classic feed system
- Rated at 1KW CW and 2KW on SSB

S-402

FULL SIZE PERFORMANCE WITH 44' ELEMENT AND A 20' BOOM
Excellent Gain and Front to Back.
Strongest Built 2 Element on 40 Meters
Good Bandwidth. Can be made to 3 element later.

new! 7-Band SWL/DX Dipole Kit
for 11·13·16·19·25·31·49 meters



Here's a low cost 7-band receiving dipole aerial kit that will pick up those hard-to-get DX stations. Everything included...just attach the wires and you're on the air! Weatherproof traps enclosed in Poly-Chem for stable all-weather performance.
MODEL SWL-7

Complete with
8 Trap Assemblies
Transmission Line Connector
Insulators
45 ft. No. 16 Tinned Copper Wire
100 ft. of 75 ohm twin lead

167

Mosley Electronics Inc. 1344 Baur Boulevard St. Louis, Mo. 63132 1-314-994-7872 1-800-325-4016

NOW ALL THESE ANTENNAS ARE UPS **SHIPPABLE!**

Correct carrier oscillator adjustment,
good linearity
and the proper microphone
make the difference

better-sounding SSB

If you want your SSB transmit audio to sound like your voice, this article was written for you.

I have never accepted the notion that good audio died with AM. After all, isn't SSB just AM with two of the unnecessary parts removed? The question is, why doesn't SSB audio give you good audio quality all the time? Armed with some electronic test equipment and a yearning for nice sounding audio, I set out to find the answers.

The results of my research indicate that three criteria must be met to achieve transmit audio quality that compares favorably with AM: the first is smooth frequency response; the second, a wide enough passband or "window" to be able to include most of the important frequencies in a human voice; and third, distortion should be low enough so that the voice does not sound rough.

generating SSB

In most SSB transceivers the mixing of the voice (audio) frequencies and the RF takes place in a balanced modulator. The balanced modulator is really a mixer that combines the audio and RF together. However, mixing is not an accurate way to describe the process, since the output is the sum of the audio frequency and the RF, or carrier frequency, and the difference of the audio frequency and the carrier frequency. (The name "mixer" should probably have been "adder-subtracter.") The *sum* output is upper-sideband (USB). The *difference* output is lower-sideband (LSB). Since both USB and LSB come out together on the sole output terminal, the result is double-sideband (DSB). Because of the balanced design of the modulator, neither the audio nor the carrier oscillator (input) signals should appear in the output.

It is important to remember that USB is always an addition process, and that LSB is always a subtraction process. For example, with a carrier frequency of 10,000,000 Hz and an audio frequency of 440 Hz, the USB output is 10,000,440 Hz and the LSB output is the difference or 9,999,560 Hz. If a second audio frequency were also fed into the balanced modulator along with the 440 Hz signal, then two frequencies would appear on USB and two frequencies would appear on LSB. If 1000 Hz were included with the 440 Hz signal, the USB would contain two frequencies: 10,000,440, Hz and 10,001,000 Hz. LSB would also contain two frequencies: 9,999,560 Hz and 9,999,000 Hz. When a voice is applied to the input of the balanced modulator, the output becomes more complicated, since a human voice contains many frequencies, but the additive and subtractive processes still apply.

producing just one sideband

The most popular system of selecting only one sideband incorporates a filter to reject the unwanted sideband and pass the desired sideband. It is common practice to use only one filter for both sidebands. In order to do this, two different carrier oscil-

By Richard L. Measures, AG6K, 6455 La Cumbre Road, Somis, California 93066

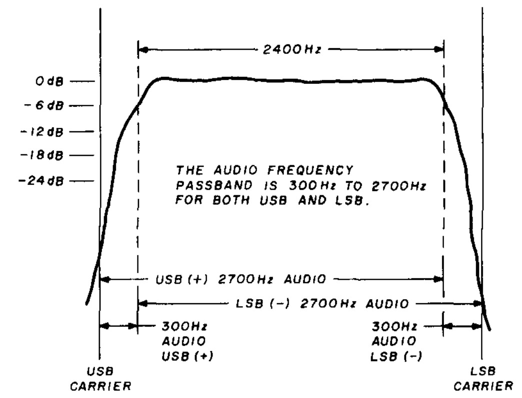


fig. 1. A typical 2400 Hz SSB filter with carrier oscillator frequencies set 300 Hz from filter window edges.

lator frequencies are used. On USB the carrier oscillator is placed about 300 Hz lower than the low frequency edge of the filter window. Since USB adds the voice and carrier frequencies, the sum will be higher than the carrier frequency and any audio frequency of 300 Hz or more will create USBs that can pass through the filter window. On lower sideband, the carrier frequency is placed about 300 Hz above the upper edge of the filter. Since LSB subtracts the audio frequency from the carrier frequency, an audio frequency of 300 Hz would just reach the upper edge of the window. In either case an audio frequency of 200 Hz would be mostly rejected since it could not add or subtract enough to each carrier frequency to reach the window. If the carrier oscillators were reset to a point 200 Hz from the edges of the window, then 200 Hz would produce a signal that will pass through the window. It is important to remember that the audio frequency itself does not pass through the window. The signals that pass through the filter are at a radio frequency, usually around 9 MHz. These signals are offset from the carrier frequency by the audio frequency. In order to receive SSB, the signal is combined with the same carrier frequency in the receiver as was used originally in the transmitter. The combining is done in another mixer called a product detector which produces audio output. This is the reverse of the process that began in the balanced modulator.

what voice frequencies are needed?

In the above example with the carrier oscillator frequencies set 300 Hz from the upper and lower frequency edges of the filter, it was shown how a 300 Hz audio signal would just reach the filter window. The next point to consider is how high in frequency can the audio signal go without missing the filter window. This is an important consideration because human speech contains high frequency sounds that are made by using the tongue to direct airflow against the teeth. This group of sounds, known as sibilants, includes S, soft C, F, and H. To do real justice to human speech, the window should allow at least 2800 Hz to pass. Allowing only 2500 Hz to pass makes a noticeable difference in the clarity of the sibilants. If a standard 2400-Hz wide filter is used, then the opposite side of the window is 2400 Hz away from the edge of the filter where the frequency generated by the 300 Hz audio signal would pass (**fig. 1**). The highest frequency audio that could pass without falling out of the window would be 300 plus 2400 or 2700 Hz. This audio would be acceptable, but would have more sibilance if the carrier frequency were moved 100 Hz farther from the filter window edge. This would move the audio passband from 400 Hz to 2800 Hz. This audio would be pleasing to most people with normal hearing. If a wider filter window were used — 2700 Hz — the audio quality would sound even better, since the carrier oscillator frequency could be reset so that the full range of important human speech frequencies — 300 Hz to 3000 Hz — could pass through the 2700 Hz window.

linearity

If the audio sounds rough and splatters on other frequencies, then linear operation is not occurring. The human ear can detect low levels of distortion. Some musicians can hear less than one part distortion in 10,000. That is −40 dB. I don't notice on-the-air distortion if it is −38 dB or better. If a station 4 kHz down the band has a 30 dB over S9 signal and his distortion products are down only 30 dB, you are going to see close to S9 splatter on the window you are listening to.

Most of the radios on the market today are fairly clean. The cleanest by far are those with vacuum tube finals employing RF negative feedback. If operated conservatively, some of the solid-state radios can also deliver a clean sound.

On my solid-state transceiver I was able to achieve −40 dB distortion products on my voice, but only after carefully setting the driver and final transistor idling current to the values called for in the service manual. I could only maintain the −40 dB distortion level if I kept the ALC level in the bottom quarter of the ALC scale. If I tried to operate with the ALC at the top of the "safe" range, the distortion increased by a factor of nine.

This test does not apply to the common two-tone method of measuring distortion. A human voice is much more complex than two tones and provides a more accurate and severe performance test. Blowing into three holes of a harmonica also works well.

The mechanism of non-linearity is essential if a mixer is to do its job of adding and subtracting. In an amplifier, non-linearity means that the amplifier is going to do some unwanted adding and subtracting of any two or more frequencies fed into the amplifier input. Human voices have many frequencies. If the linear amplifier is not linear, there will be more frequencies, and some of them are likely to land on someone else's conversation on a nearby frequency.

measuring distortion

Distortion can be measured with a separate receiver, provided it has an S-meter of known accuracy. The linearity of the S-meter is the essential factor in making this test. The number of microvolts that equals S9 does not matter. Use a short clip-lead for the receiver antenna and a 20 dB attenuator. Tune to the frequency on which you are transmitting and watch the S-meter while you speak into the microphone. Note the S-meter reading and retune the receiver either 4 kHz above or 4 kHz below the transmitter frequency. Speak again and note the S-meter reading. The dB difference is your distortion level. A reading of −40 dB is excellent. A reading of −30 dB is not quite anti-social, but −20 dB is definitely in the "skunk" category. The all-time record worst distortion I have witnessed was −9 dB — this is *not* the way to win friends. Measuring distortion as described works best on your own transmitter. It is possible to use the same method on the air to measure someone else's distortion, but fading signals can make measurements inaccurate. To do this, a real antenna is more useful than the clip lead. I recommend 4 kHz spacing to ensure that your receive window does not appreciably overlap the other operator's transmit window. If the windows touch, the measurement will mean nothing, since you won't be able to separate the distortion from the desirable audio frequencies.

design defects

During my first SSB experiments I was amazed to learn that listeners could detect a small change in flatness of frequency response. If your transmitter has a 3 dB loss at the high end, the lack of sibilance is noticeable. Many of the modern rigs on the market today have a built-in rolloff of the high frequency transmit and receive audio. The amount of high frequency (treble) rolloff varies from 4 dB to 10 dB in the rigs that I have measured. Usually the receivers have the more uneven audio response.

The usual culprit in the transmitter section can be found at the collector of the microphone amplifier. In my transceiver there was a 0.015 microfarad capacitor from the collector to ground. About 60 percent of my 2900 Hz audio was going to ground at this point. I replaced this with a 0.001 microfarad capacitor and the treble passed through unscathed. Since the purpose of this capacitor is to prevent your own RF from getting into your audio, a non-inductive capacitor such as a disc ceramic type is advised.

I noticed that the high frequency audio in my receiver seemed attenuated. My test equipment confirmed a 9.5 dB rolloff at 2900 Hz. This meant that 11.2 percent of the audio was making it to the speaker at that frequency and that 88.8 percent was not. The culprit in this case was a large-value capacitor at the output of the product detector. The value used was 0.033 microfarad. This capacitor had a reactance of only 1600 ohms at 2900 Hz. The audio impedance of the product detector was about 5000 ohms. Shunting a 1660 ohm capacitor to ground is bound to be a spoiler. The purpose of this capacitor is to let the audio pass and to suppress the RF energy. Again the capacitor is necessary — but the value must be picked with some prudence. (Bigger isn't always better.) I changed the capacitor to 0.0033 microfarad. The audio sparkled. Voices were easier to understand.

microphones

Anyone who reads the advertising for microphones knows that you need a special microphone for SSB. It sounded reasonable to me, so I bought two microphones with lots of "punch." One was a crystal element type. The other microphone had a rising response dynamic element. Both microphones had more highs than lows — just the ticket to "get more DX." I also owned a flat response electret condenser microphone.

Early one winter morning I was working a DX station on 80 meters. I asked the DX station if he would listen to three different microphones and select the one that was easiest to copy under adverse conditions. I tried microphone number 1, number 2, and number 3. The microphone that produced the best copy was microphone number 3 — the condenser microphone — and the same microphone my local friends preferred to listen to. To be sure, this was only one test, but it certainly cast doubt on the traditional view of what it takes to be understood on SSB. Perhaps we don't really need to sound like ducks after all. Many amateur radio transceiver manufacturers now offer condenser microphones. Most of the microphones worn by television newscasters are of this type.

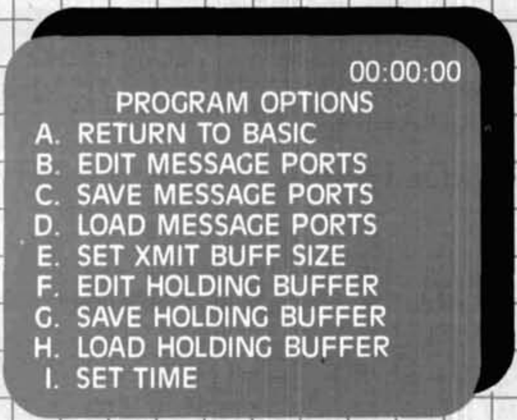
adjusting the carrier oscillators

The most important adjustment in an SSB transceiver is the carrier oscillator. This adjustment sets

KANTRONICS SOFTWARE
Hamsoft,™ Hamtext,™ and Amtorsoft™

Kantronics has led the amateur community in software and total computer communications systems with our original program, **HAMSOFT**. With five-computer compatibility and reasonable prices **HAMSOFT** has become the industry standard. **HAMSOFT** includes split screen display, type ahead buffer, message ports, and complete keyboard control for Morse Code, Radioteletype, and ASCII communications. With THE INTERFACE or INTERFACE] [, **HAMSOFT** can make any of five computers a complete amateur communications terminal. All programs are on a ROM board, except the Apple diskette.
VIC-20 – $49.95, ATARI – $49.95, APPLE – $29.95, TRS–80C – $59.95, TI-99/4A – $99.95

HAMTEXT is our advanced CW/RTTY/ASCII program for the VIC-20, COMMODORE 64, and APPLE computers. **HAMTEXT** gives you the ability to store incoming messages in the computer's memory, transmit files directly from tape or disk, and use your computer to its fullest potential. Features like Diddle, Time Transmission, Text Transmission, Printer Outputs, and Word Wraparound, make **HAMTEXT** the program for the serious amateur. **HAMTEXT** was created with input from our users as guidelines, and with total use of the computer in mind.
Suggested Retail **$99.95**



On January 27th, 1983, AMTOR, Amateur RadioTeletype Over Radio, became a legal mode for the amateur service. AMTOR is an essentially error-free radioteletype form of communication. **AMTORSOFT,** Kantronics' newest software package, gives your computer the ability to become an AMTOR communications terminal when used with The Interface or Interface] [. **AMTORSOFT** is currently available for the Apple, VIC-20, and COM-64 computers. **AMTORSOFT** brings you the newest in computer-amateur communications at an affordable price.
Suggested Retail **$89.95**

For more information see your Kantronics dealer, or contact:
Kantronics 1202 E. 23rd Street Lawrence, KS 66044

the position of the audio frequency window on both RECEIVE and TRANSMIT. The only test equipment needed is a common audio generator that can be adjusted for a few millivolts and an RF wattmeter-dummy load. Connect the generator to the microphone input. Adjust the audio frequency for 1000 Hz. Set the level at a value that is about half of the maximum output power — for example, 40 watts. Adjust the generator higher in frequency until the wattmeter reads one quarter of the wattage produced when the audio frequency was 1000 Hz. This 25 percent power point is the minus 6 dB rolloff. Move the audio frequency lower until the power drops to 25 percent again. All of the frequencies between these two audio frequencies comprise your transmit window. If you find that your high frequency term is less than 2800 Hz at the rolloff point, your carrier needs to be moved farther away in frequency from the filter window. The low frequency rolloff should be 300 Hz or higher, but not above 400 Hz or it will sound thin (or tinny). If you are using a 2000-Hz wide filter you have a problem unless you want to sound like a 1910 model telephone. Wider filters are available for many rigs, direct from the manufacturer. I bought 2700 Hz filters for both of my transceivers.

Some people believe that a wider filter will impair reception because of increased splatter from adjacent stations. Most of the splatter on the ham bands is due to distortion products coming from the other fellow's transmitter; distortion products such as these can never be eliminated with a receive filter because the distortion is on the same frequency as the station you are trying to listen to.

There are devices on the market that will correct for a slight loss in treble transmit response caused by a 15-cent capacitor being the wrong value. But if the carrier oscillator is misadjusted, these devices will not be effective. For example, if the carrier oscillator is set so that the high frequency rolloff is 2200 Hz, the SSB filter is going to have the last word on what gets through. Boosting the treble with an accessory can make the problem less noticeable, but will not restore the high frequency rolloff to 2800 Hz as it should be.

Carrier oscillators can also be adjusted by ear. The rule is to simply set it to where it sounds good. While this may take a little longer than it would using test equipment, the method works. The only problem lies in finding a listener who is not afraid to tell you what you really sound like so you can know which way to move the adjustment. Some people don't want to hurt your feelings; they don't like to give a "bad" report.

Clean audio is a pleasure to listen to on the air, and rotten, splattering audio is a blight on the bands.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

the groundplane loop antenna

Every once in a while an interesting antenna comes along that causes me to ask, "Why didn't I think of that idea?" A case in point is the groundplane loop antenna described by Hans Wuertz, DL2FA, in *cq-DL*, the monthly publication of the German Amateur Radio Club. An English translation of the pertinent data on the loop was recently published in *Radio Communication*, the journal of the Radio Society of Great Britain (RSGB).

The basic configuration of the DL2FA loop is shown in **fig. 1**. The design is a half of a full-wave loop antenna with the other half formed by the ground image. With a 0.2 wavelength half-loop for the lowest operating frequency, DL2FA claims that the antenna can be tuned to cover a 2-to-1 frequency range (3.5 to 7 MHz, for example).

Even though the radiation resistance of the antenna is low, the efficiency of the antenna is excellent, and at 3.5 MHz the field strength is only 2 dB less than a full-size quarter-wave vertical antenna. At 7 MHz, the field strength is within 0.5 dB of a full-size vertical.

To achieve low loss, the loop and ground return are constructed of 3/8-inch (approximately 10 mm) diameter copper tubing. The copper tubing that runs along the surface of the ground is soldered to a groundplane or mat made of chicken-wire (size not specified).

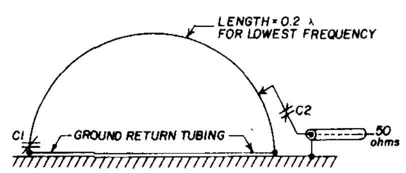


fig. 1. The DL2FA groundplane loop with gamma match feed. Tap point is approximately 0.04 wavelength. Ground return tubing is soldered to ground screen. Semicircle length is 27 feet 6 inches for 80-40 meter operation.

Measured data for the groundplane loop is tabulated in **table 1**.

FIBS revisited

A few years ago 80-meter operators in southern California and Arizona were surprised to hear one of the rarest broadcasting stations in the world: the *Falkland Islands Broadcasting Station* operating on 3.958 MHz. The signals would appear on an otherwise dead band in the late afternoon hours for a few moments and then disappear. The signals seemed to peak in the spring and fall.

Reports indicate the station is being heard once again. It seems that they are using single sideband with carrier, with the audio present on the upper sideband. Reception reports on this unusual station would be appreciated. The programs consist mostly of pop and disco music with BBC news on occasion.

It is thought that the FIBS propagation into the Northern Hemisphere is by other than normal ionospheric reflection. One theory is that the signal (and other DX signals near that frequency) may be propagated by a "whistler" path which extends into outer space far beyond the ionosphere.

a simple 50 to 75 ohm RF transformer

Shown in **fig. 2** is a simple high-frequency transformer that provides wideband transformation between 50 and 75 ohm unbalanced lines. The design is by JA1AKP, and appeared in a recent issue of *CQ-ham radio* (Japan). The transformer is wound on a FT-114 (μ = 125) No. 61 ferrite core (Amidon FT-114-61) having an outside diameter of 1.142 inches and an inside diameter of 0.75 inch. A trifilar winding of No. 18 wire is used, with two coils having 8 turns and one coil having 4 turns.

A 100 pF mica capacitor to ground is placed at the junction of the two 8 turn coils and a 10 pF capacitor to ground is placed at the 75 ohm port. The units are 500 volt rated. The balun is designed for 3.5 to 30 MHz at the 100 watt average power level.

MISSOURI RADIO CENTER 1-800-821-7323

KENWOOD TS-430S	ICOM IC-740	YAESU -NEW FT-77
		

KENWOOD TS-430S
- All Bands
- General Coverage
- 200 Watts
- Dual VFO's
- 8 Memories

ICOM IC-740
- 1.8 to 30 MHZ
- Super Receiver
- 200 Watts
- Selectable IF / PBT Tuning

YAESU -NEW FT-77
- Extremely Compact
- 200 Watts
- 3.5 to 30 MHZ
- Inexpensive

ANTENNA SALE

CUSHCRAFT		HYGAIN TOWERS		BUTTERNUT		HYGAIN	
A-3	$210	HG37SS	$ 649	HF6V	$109	TH5MK2S	$318
A-4	$279	HG52SS	$ 919	KLM		TH7DXS	$378
R-3	$269	HG54HD	$1429	KT34A	$299	TH3MK3S	$218
AV-5	$96	HG70HD	$2339	KT34XA	$449	TH3JRS	$158
214-FB	$78	HG50MTS	$ 749	144-148LBA	$ 69	TH2MKS	$138
32-19	$92					18AVT/WS	$ 94
40-2CD	$279	LARSEN	CALL	AEA	CALL	18HTS	$335
						V2S	$ 37

CALL "TOLL FREE" FOR ALL ANTENNAS & ACCESSORIES

CALL FOR HYGAIN TOWER PACKAGES.

2900 N.W. VIVION RD. / KANSAS CITY, MISSOURI 64150 / 816-741-8118

✓ 166

NOW THERE ARE THREE!

The Dayton HAMVENTION will present three awards to selected recipients at the 1984 HAMVENTION on April 27, 28, 29, 1984. In addition to the AMATEUR OF THE YEAR and the SPECIAL ACHIEVEMENT awards, a third award for TECHNICAL EXCELLENCE will be given annually for outstanding accomplishment specifically oriented to the technical aspect of amateur radio.

Nominations are requested for each of these prestigious awards. The deadline for submission is April 1, 1984. Write for additional information.

AWARDS COMMITTEE
1984 Dayton HAMVENTION
P.O. Box 44
Dayton, Ohio 45401

ORR BOOKS

BEAM ANTENNA HANDBOOK
by Bill Orr, W6SAI

Recommended reading. Commonly asked questions like: What is the best element spacing? Can different yagi antennas be stacked without losing performance? Do monoband beams outperform tribanders? Lots of construction projects, diagrams, and photos. 198 pages. ©1977. 1st edition.

☐RP-BA Softbound $7.95

SIMPLE LOW-COST WIRE ANTENNAS
by Bill Orr, W6SAI

Learn how to build simple, economical wire antennas. Apartment dwellers take note! Fool your landlord and your neighbors with some of the "invisible" antennas found here. Well diagramed. 192 pages. ©1972.

☐RP-WA Softbound $7.95

THE RADIO AMATEUR ANTENNA HANDBOOK
by William I. Orr, W6SAI and Stuart Cowan, W2LX

Contains lots of well illustrated construction projects for vertical, long wire, and HF/VHF beam antennas. There is an honest judgment of antenna gain figures, information on the best and worst antenna locations and heights, a long look at the quad vs. the yagi antenna, information on baluns and how to use them, and new information on the popular Sloper and Delta Loop antennas. The text is based on proven data plus practical, on-the-air experience. **The Radio Amateur Antenna Handbook** will make a valuable and often consulted reference. 190 pages. ©1978.

☐RP-AH Softbound $7.95

ALL ABOUT CUBICAL QUAD ANTENNAS
by Bill Orr, W6SAI

The cubical quad antenna is considered by many to be the best DX antenna because of its simple, lightweight design and high performance. You'll find quad designs for everything from the single element to the multi-element monster quad, plus a new, higher gain expanded quad (X-Q) design. There's a wealth of supplementary data on construction, feeding, tuning, and mounting quad antennas. 112 pages. ©1977.

☐RP-CQ Softbound $6.95

Please add $1.00 to cover shipping and handling.

HAM RADIO'S BOOKSTORE
GREENVILLE, NH 03048

ancient modulation

Since the late 1950's single sideband has reigned supreme on the Amateur bands. Users of amplitude modulation ("ancient modulation") have been greeted with derision and have gradually retreated to obscure regions of 160 and 10 meters. Many newly-licensed Amateurs have never heard an AM ham signal!

While Amateurs may pride themselves that sideband has provided them with a quantum leap ahead in communications reliability, they may forget that amplitude modulation is still the prime communication medium in the world. After all, the broadcast band is full of AM signals, and there are a lot of them!

Generally speaking, while the quality of Amateur SSB voice transmission has deteriorated,* the quality of AM transmission has improved. The modern term for broadcast quality is "transparency" — the transmitting system must be "transparent" with regards to the modulating signal.

While much thought and ingenuity have gone into AM transmission in the last decade, most of it has bypassed the Radio Amateur. New techniques, such as high-level pulse-duration modulation, AM stereo and audio processing are unknown in the ham bands, but noise reduction systems, equalizers, delay/reverb effects, level controllers, low frequency extenders and other processing techniques are routinely used by AM broadcasters to make their audio more realistic and outstanding.

On the receiving end of the line, even the less expensive clock-radio combo receivers have audio systems that make the average ham receiver blush with shame.

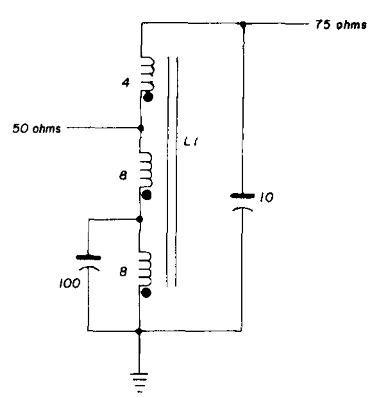


fig. 2. Wideband transformer to match 50 ohms to 75 ohms over the range of 3.5 to 30 MHz. Amidon FT-114-61 (or equivalent) core is used. Trifilar winding of No. 18 wire consists of two coils of 8 turns and one coil of 4 turns. See text for further details.

Even though most ham signals are "strained" through a narrow-band IF filter, there is no reason why the rest of the receiver should be below par as far as audio quality goes.

Recently I put a little audio feedback around the output stages of my trusty ham receiver, replaced the 19-cent (?) output transformer with one that had some iron in it, and ran the whole works into a spare stereo speaker. My goodness! I didn't recognize the sound of the ham bands! A lot of signals (whose operators previously sounded as if they were talking into a tin can at the end of a long string) actually sounded quite pleasant, and some signals sounded downright natural!

I then wondered what my transmitted audio quality was like. I put a good audio generator into the transmitter and looked at the audio signal as it entered the balanced modulator. I didn't like what I saw. Any resemblance to a sine wave was minimal.

It was no job at all to add a feedback resistor and to change another resistor in the low-level audio stages to make the waveform look very passable. Now, what came out of the exciter audio system bore a close similarity to what went in.

At this stage I stopped as I became bogged down into an interminable discussion of microphones with friends who knew a lot more about them than I did. The consensus was that the best way to improve audio quality was to throw away the microphone that came with the exciter and buy a good one! Without exception, all of my friends who had particularly pleasing and "punchy" signals on the air had replaced their standard transmitter microphones with different (and more expensive) units.

So there it is. The "ancient modulation" techniques of 1984 and the techniques used by up-to-date broadcasters certainly have some merit for use in the Amateur bands. Which of these new techniques should we examine? I throw the column open to discussion from the readers. (What's the input from hams who work in broadcasting? I'd especially like to hear from *you.*)

table 1. Groundplane loop dimensions and performance data. (Courtesy of *Radio Communication*, published by the Radio Society of Great Britain and available from Ham Radio's Bookstore, Greenville, New Hampshire 03048.)

band	semicircle length	C1 (pF)	bandwidth (−3 dB points)	efficiency % (MHz)	comparison with 1/4 wave vertical
3.5 - 7.0	27 ft 6 in (8.4 m)	332	5.7 kHz	70 (3.5)	−1.91 dB
			to 67 kHz	96 (7.0)	−0.55 dB
7.0 - 14.0	13 ft 9 in (4.2 m)	184	11 kHz	77 (7.0)	−1.52 dB
			to 147 kHz	97 (14.0)	−0.50 dB
14 - 28	6 ft 10 in (2.1 m)	102	24 kHz	83 (14.0)	−1.22 dB
			to 323 kHz	98 (28.0)	−0.47 dB

staggered stacking

It is common practice in the VHF bands to stack two or more high-gain Yagi beams to obtain increased gain. Adjustment of the stacking distance can improve sidelobe reduction of the array.

Experiments conducted by G.J. McDonald, VK2ZAB, and reported in the Australian magazine *Amateur Radio*, indicate that an improved

*See "better-sounding SSB," page 58 — Editor

✓ 131

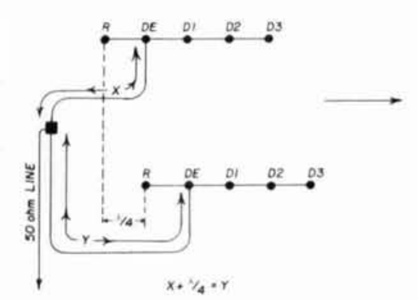


fig. 3. The VK2ZAB array employing staggered stacking. Bottom Yagi is advanced one-quarter wavelength in front of upper array and extra quarter wavelength is added to the phasing line. Front-to-back ratio is improved by this modification.

front-to-back ratio in a Yagi stack can be achieved by staggering the antennas. That is, the bottom Yagi of each vertically stacked pair is advanced one-quarter wavelength on its mounting so that it projects one-quarter wavelength in front of the upper array (**fig. 3**). The phase lead in the forward direction is cancelled by adding an extra quarter wavelength to the phasing harness connected at the bottom Yagi, thus insuring that the current to both arrays arrives from the feed junction in phase.

Signals arriving at the rear of the array are subject to a 90-degree lag by virtue of the position of the bottom Yagi relative to the top one, plus the additional 90-degree lag caused by the extra length of phasing line.

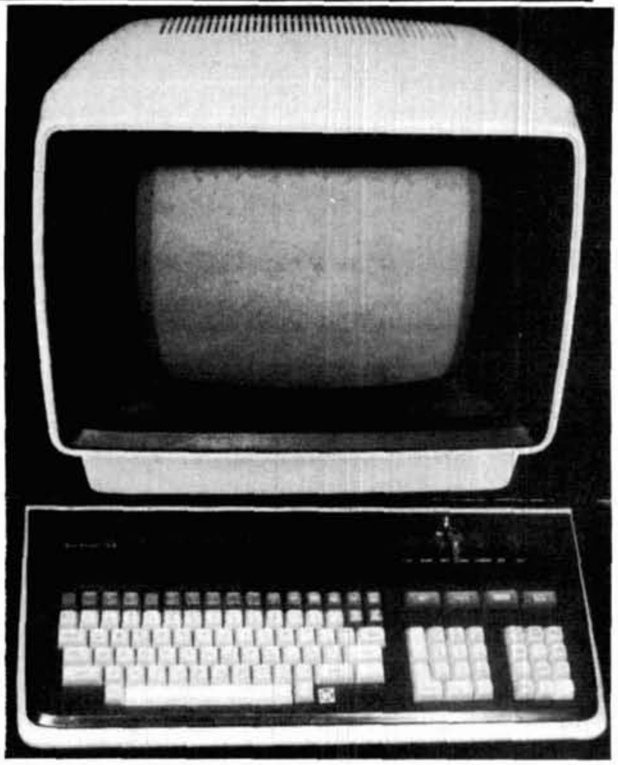
Results? With a conventional stack of two Yagis, the measured front-to-back ratio was about 12.5 dB. The staggered stack provided a front-to-back ratio of 24 dB, for an improvement of 11.5 dB. And that is equivalent to about 2 "S" units — enough to make the difference between just being able to copy a DX signal through QRM from the rear of the array and copying it comfortably!

Final measurements showed the staggered stack had about 0.25 dB more gain than the conventional stack and also reduced the sidelobes to some extent.

ham radio

John J. Meshna Jr., Inc.

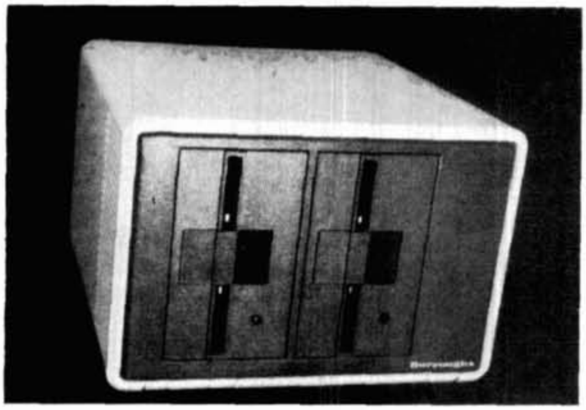
19 Allerton Street • Lynn, MA 01904 • Tel: (617) 595-2275



SELF STANDING COMPUTER TERMINALS

We acquired a small number of these beautifully made computer terminals which were made by a major U. S. manufacturer. We do not know all the details about them at press time, but we can tell you that someone lost over **$2000** on each of them. They lose you win. The terminals feature 3 micro-processors for powerful capabilities, 106 key, Hall Effect ASCII keyboard, 10 user defineable keys, EAROMs, 16K RAM, 48K ROM, serial RS 232 asynchronous data communications, (synchronous optional), selectable baud rates of 75-38.4K BPS, high resolution, 12" green screen, composite video monitor, 80 X 25 line scrolling display, built-in reverse video option, self-contained, lightweight, tightly regulated switching power supply & more than can be fit in this space. The terminals were designed to be daisy chained around a central host computer and used as individual work stations. The host system could then selectively address any machine in the network for any message it may have. All units are visually inspected prior to shipment. An operators manual is provided w/ each unit.
Shpg. wt. 55 lb. model no. MT 686 $289.00
With the addition of our TP 420 dual FDD system below, you can create your own office system.

We offer the following as options: schematic pac. 3 lb.	$ 10.00
USRT for synchronous data comm. w/ installation data	$ 10.00
25' RS 232 cable, 1 male & 1 female DB 25 connector	$ 20.00



TP 420 DUAL MINI-FLOPPY DISC SYSTEM

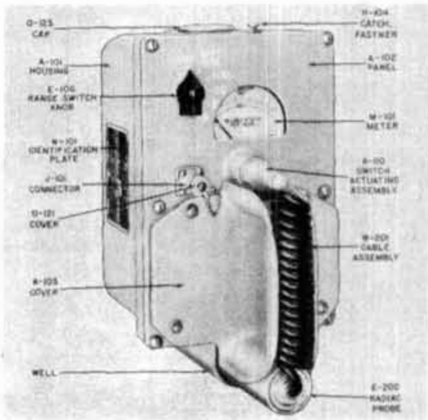
The TP 420 is an extremely versatile mini floppy disc drive system. It consists of 2 Shugart SA 400 5¼" floppy disc drives, associated logic, controller card, power supply, cooling fan, and case. The TP 420 has a built in controller card which features: Z 80 A CPU, Z 80A DMA, Z 80A CTC, Intel 8271 controller chip, 6K RAM, ROM, plus other goodies. We have been told that the serial interface controller card within the TP 420 will support up to 4 8" drives from the unused port on it. The con troller card can be easily removed should you wish to use it on some other system. Also built in is a tightly regulated, switching power supply which runs on 115/230 v 50/60 hz.. The TP 420 is shipped w/ the interface cable for the MT 686, data, & schematics. Shpg. wt. 22 lb. Stock no. TP 420 $300.00

PDR-27 NAVY RADIATION METER

Just released by the US Navy. They appear to be in excellent condition and include the fitted aluminum transit case. Batteries not furnished but are available in most electronic supply houses. 4 ranges 0.5 to 500 mr/hr. Removeable hand probe, detection of Beta and Gamma radiation. With todays world conditions and perhaps proximity to a nuke power station, it might provide a little insurance to own one of these instruments. With no facilities to check or test, we offer AS IS, visually OK Schematic provided with each. We have some accessories and offer as an option although not required for operation.
Shipping wgt. 22 lb. PDR-27 **Rad Meter $50.00**

PDR-27 phones $7.00	Approx. 100 page Instr. Book $10.00
Hi Sensitivity GM tube $10.00	Low Sensitivity GM tube $5.00

The above listed tubes are already installed in the meter.
We are offering these as spares if desired.



PHONE ORDERS accepted on MC, VISA, or AMEX
No COD's. Shpg. extra on above.
Send for free 72 page catalogue jam packed w/ bargains.

164

The Circular Advantage

For OSCAR 10 and Russian Satellite Communications

2M-14C

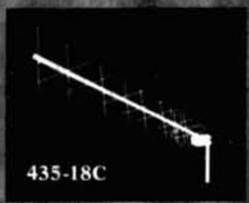
KLM's Circular Polarized antennas have been specifically designed to optimize OSCAR 10 and Russian satellite operation. Quality workmanship and superior design, yield virtually perfect circular patterns over the satellite operational bandwidth. Enjoy less Multi-Path Distortion, less Flutter, Fade, and better S/N Ratios, with comparable performance on transmit.

Both the 2M-14C and 435-18C sport virtually unbreakable 3/16" rod parasitic elements anchored thru the boom, folded dipole driven elements produce excellent physical and electrical symmetry for years of constant performance.

Specifications: (2M-14C)

BANDWIDTH: .. 144–150 MHz	BOOM LENGTH: .... 12'9"
GAIN: .... 11 dBdc	VSWR: 1.2:1
BEAMWIDTH: .... 48°	WINDLOAD: .... 1.25 sq. ft.
FEED IMP: ..... 50 ohm unbal.	WT. (LBS): 7.5
BALUN: 4:1,2KW	ELLIPTICITY: ..... ±3 dB Max.
CIRCULARITY SWITCHER: .... INCLUDED	

The 435-18C is a star performer, an optional CS-2 circularity switcher puts left, and right-hand circular control in your shack, and doubles as a two port divider/impedance transformer for single feed line convenience.



435-18C

Specifications: (435-18C)

BANDWIDTH: .. 420–450 MHz	GAIN: .... 12 dBdc
BOOM LENGTH: .... 7.3 ft.	VSWR: 1.5:1
BEAMWIDTH: .... 44°	FEED IMP: ..... 50 ohm unbal.
WT. (LBS): 4.5	BALUN: 2–4:1. 1KW
MAST DIA: ..... Cen–Rear/1½"	ELLIPTICITY: ...... 3dB MAX.
CIRCULARITY SWITCHER .... (CS-2) OPTIONAL	

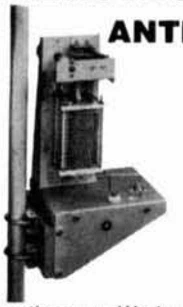
See your local KLM dealer or write for our complete catalog

KLM electronics Inc.
P.O. Box 816, Morgan Hill, CA 95037

✓ 156

• NEW • NEW • NEW • NEW • NEW • NEW • NEW • NEW • NEW • NEW • NEW • NEW • NEW • NEW •

REMOTE CONTROLLED ANTENNA TUNER



Installs outside at the antenna • Maximum efficiency • Optimum impedance match • Fingertip control • Works all bands with low VSWR 160 thru 10 meters continuous • Works with all antennas, doublets, inverted V's, verticals, single band, multiband, trap or parallel type elements. Also available in mobile version for full band coverage from driver's seat.

Model VT-4 Home installation
Model VT-3 Mobile installation
ONLY $159.00 ✓ 189

For more information write:
VECTOR RADIO
PO Box 1166 • Cardiff, CA 92007

FCC LOWERS REQUIREMENTS — GET YOUR RADIO TELEPHONE LICENSE

FCC changes make obtaining a High-level Radio Telephone License much easier now. Eliminate unnecessary study with our short-cuts and easy to follow study material. Obtaining the General Radio Telephone License can be a snap! Sample exams, also section covering Radar Endorsement.

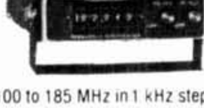
A small investment for a high-paying career in electronics.

$19.95 ppd.
Satisfaction Guaranteed

SPI-RO DISTRIBUTING
P.O. Box 1538
Hendersonville, N. C. 28793

✓ 181

SYNTHESIZED SIGNAL GENERATOR



MADE IN USA

MODEL SG100D $349.95 plus shipping

• Covers 100 to 185 MHz in 1 kHz steps with thumbwheel dial • Accuracy 1 part per 10 million at all frequencies • Internal FM adjustable from 0 to 100 kHz at a 1 kHz rate • Spurs and noise at least 60 dB below carrier • RF output adjustable from 5-500 mV at 50 ohms • Operates on 12 Vdc @ 1/2 Amp • Available for immediate delivery • $349.95 plus shipping • Add-on Accessories available to extend freq. range, add infinite resolution, voice and sub-audible tones, AM, precision 120 dB calibrated attenuator • Call for details • Dealers wanted worldwide.

VANGUARD LABS
196-23 Jamaica Ave., Hollis, NY 11423
Phone: (212) 468-2720

✓ 187

VHF meteor scatter communications

Sporadic meteor activity improves reliability

Meteors are space junk — typically, small bits of stone or metal from a passing comet, or perhaps leftovers from the formation of our solar system.

When a meteor enters earth's atmosphere it almost always burns up. Its violent passage produces heat, light, and an ionized trail of gases in the upper atmosphere which reflect or reradiate radio signals, an effect known by those who observed the return of American astronauts from space. Not long ago, the crews of the space shuttle *Columbia* lost contact with the ground for several minutes during reentry because of the reflective properties of ionized gases created by the tremendous heat of reentry.

A few Amateurs have taken advantage of these ionized trails to communicate beyond the VHF horizon, using various modes of transmission. Until now, however, communications using the reflective and refractive qualities of meteor trails have been restricted to periods of stream or shower meteors, because only these periods provide a level of ionization high enough to support two-way communication using Morse code or voice modes.

Once again the Amateur community stands on a technological frontier, for with the aid of today's microprocessor systems, some of the more than 100 million meteor trails that occur daily can be used even though their peak reflective trail lasts only several milliseconds.

Perhaps the most appealing aspect of the meteor-burst concept is the use of bands "closed" to normal communication because of poor conditions. Sporadic meteors occur 24 hours a day, 365 days a year. This means you need not store that 6-meter rig in the closet during minimal sunspot activity; you can go right on using it to communicate in a new way using new transmission techniques.

shower and sporadic meteors

Ionized paths created by the passage of sporadic and shower meteors allow two-way radio communication by returning a portion of the signal to the earth much the same as the ionosphere does at frequencies below 30 MHz. Current Amateur meteor-scatter operations take place mainly during large meteor showers. These predictable showers are composed of meteors large enough to cause trails lasting several minutes; the trails are long enough to allow operating techniques to take place at humanly controllable speeds.

Meteor showers or *stream meteors* occur at predictable times during the year (see **table 1** and **fig. 1**), with peak activity during June, July, August, and December. Communication using the shower meteors is a VHF speciality in the same class as using sporadic E, tropospheric scatter, and ducting conditions. (In contrast, the sporadic meteor-scatter user need not be concerned with meteor-shower schedules or optimum direction calculations.)

Because they appear to radiate from certain points

By Lloyd Vancil, AI7J, 520 Del Sur Way, Oxnard, California 93030

in the sky, meteor showers are usually named for a constellation visible nearby: for example, the Geminids appear to come to Earth from the constellation Gemini. As the constellation moves across the sky, communication is established and maintained by keeping the antenna trained on Gemini as the Earth rotates.

Unlike shower-borne stream meteors, *sporadic meteors* bombard the earth's atmosphere constantly. An average of 100 million meteors large enough to leave an ionized trail enter the earth's atmosphere daily. The usable trails occur at an altitude of 50 to 75 miles (80 to 120 km) and must last more than a few hundred milliseconds (**table 2**) in order to be usable.

Sporadic meteors are the small meteors characterized by the "ping" noise heard by VHF DXers — hence the name, "ping jockey." Sporadic meteors are the ones used to communicate over distances up to about 1000 miles (1600 km) by relatively new data acquisition systems.[1]

Although sporadic meteors appear continuously, their most intense activity is between 0400 and 0800

table 1. Meteor shower data for 40 degrees north latitude. Peak days, meteor velocities, and hourly rates are given, in that order, under shower name.

shower and date (peak date) (velocity) (rate)	optimum time/path (local standard)	antenna offset direction	notes
January 1-4	0220-0740/NW-SE	SW	intense, but lasts
QUADRANTIDS	0740-0900/E-W	S	only several hours
Jan. 3, 42km/s	0900-1430/NE-SW	SE	
50/hr			
May 1-6	0410-0630/NE-SW	NW	
ETA AQUARIDS	0630-0830/E-W	N	
May 4, 64km/s	0830-1050/NW-SE	NE	
15/hr			
June 1-15	0515-0745/N-S	W	intense daylight
ARIETIDS	0745-0920/NE-SW	NW	shower, but mostly
June 7-8, 39km/s	0920-1015/E-W	N	small particles
60/hr	1015-1155/NW-SE	NE	
	1155-1425/N-S	E	
July 26-31	0100 /NE-SW	NW	
DELTA AQUARIDS	0100-0330/E-W	N	
July 29-30, 43km/s	0330 /NW-SE	NE	
20/hr			
August 10-14	2330-0430/NW-SE	SW	reliable; many
PERSEIDS	0430-0730/E-W	S	large particles
Aug. 12-13, 61km	0730-1230/NE-SW	SE	
50/hr			
October 18-23	0015-0145/N-S	W	
ORIONIDS	0145-0350/NE-SW	NW	
Oct. 21-22, 67km/s	0350-0500/E-W	N	
20/hr	0500-0710/NW-SE	NE	
	0710-0840/N-S	E	
November 14-18	0200-0430/N-S	W	Periodic, spectacular
LEONIDS	0430-0600/NE-SW	NW	every 33 yrs; poor in
Nov. 16-17, 72km/s	0600-0700/E-W	N	between. Next peak in
10/hr	0700-0840/NW-SE	NE	1999.
	0840-1100/N-S	E	
December 10-14	2115-0100/N-S	W	reliable, many large
GEMINIDS	0100-0200/NE-SW	NW	particles
Dec. 12-13, 35km/s	0200-0230/E-W	N	
60/hr	0230-0330/NW-SE	NE	
	0330-0715/N-S	E	
December 21-23	2200-1600/E-W	S	
URSIDS			
Dec. 22, 35km/s			
13/hr			

hours, local time, because this is the time when the local sector turns toward the direction of the Earth's travel through space. This is a solar system event, in that the occurrence is approximately the same at local time at any point on the Earth — just as daybreak or moonrise.

The peak in daily variation in sporadic meteor activity occurs when a sector of the Earth's surface becomes the "leading edge" of the planet's progress through space, effectively "leading" the sweep of the planet through space.

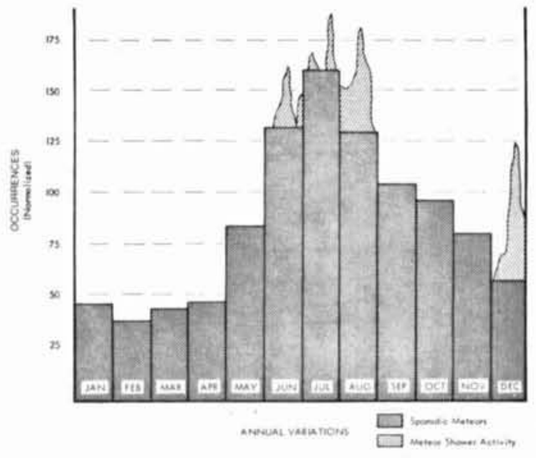


fig. 1. Normalized meteor activity by month.

From late afternoon through early evening, the "leading-edge" portion of Earth's surface changes to the "trailing edge;" only those meteors traveling fast enough to catch up are caught in Earth's gravitational field. Of these, only some will produce a usable trail. The late afternoon events are much further apart and meteors move much more slowly relative to the Earth's surface, resulting in greatly increased waiting time between usable paths (**fig. 2**).

Because the number of usable sporadic trails varies on an annual and daily basis, astronomers have concluded that sporadic-meteor materials are spread fairly evenly throughout the solar system, but confined to the plane that intersects the planets.

history

Mankind has been aware of meteors — so called "shooting stars" — since his first view of the night sky. The radio disturbance caused by meteors is a relatively recent discovery; Skellett,[2] in 1932, was the first to link an increase of noise in a receiver to the passage of meteors through the atmosphere. Allen[3] studied the meteor-scatter propagation of signals from an FM transmitter at Paxton, Massachusetts, in 1934. In this work, he identified both the shower and sporadic types of meteor trails. Virtually all advances in the field to date are based on his and Skellett's works.

The feasibility of meteor-burst communications was first tested by the National Bureau of Standards

table 2. Order of magnitude estimates of the properties of sporadic meteors.

	mass (grams)	radius		number of this mass or greater swept up by the earth each day	electron line density (electrons per meter of trail length)
particles pass through the atmosphere and fall to ground	10^4	3.15in	(8 cm)	10	10^{18}
Particles totally disintegrated in the upper atmosphere	10^3	1.57in	(4 cm)	10^2	10^{18}
	10^2	7.87×10^{-1}	(2 cm)	10^2	10^{18}
	10	3.15×10^{-1}	(0.8 cm)	10^4	10^{18}
	1	1.57×10^{-1}	(0.4 cm)	10^5	10^{17}
	10^{-1}	7.87×10^{-2}	(0.2 cm)	10^6	10^{16}
	10^{-2}	3.15×10^{-2}	(0.08 cm)	10^7	10^{15}
	10^{-3}	1.57×10^{-2}	(0.04 cm)	10^8	10^{14}
	10^{-4}	7.87×10^{-3}	(0.02 cm)	10^9	10^{13}
	10^{-5}	3.15×10^{-3}	(80 MICRONS)	10^{10}	10^{12}
Approximate limit of radar measurements	10^{-6}	1.57×10^{-3}	(40 MICRONS)	10^{11}	10^{11}
	10^{-7}	0.787×10^{-3}	(20 MICRONS)	10^{12}	10^{10}
	10^{-8}	0.315×10^{-3}	(8 MICRONS)	?	?

Note: Information from K. Davies, "Ionospheric Radio Propagation," National Bureau of Standards Monograph #80, April, 1965.

The small dish that captures all the entertainment.

WILSON MICROWAVE SYSTEMS, INC.

Only Wilson Microwave Systems can give you the versatility of hand-held control of the total satellite television spectrum at such a remarkably low price.

Total System Design.

From the solid steel antenna to the state-of-the-art electronic receiver and hand-held control unit, Wilson gives you the most complete, integrated system you can own.

At Wilson Microwave Systems, we put the world of entertainment in the palm of your hand.

BUILT BY YAESU
1 year warranty on receivers
4 year limited warranty on dish

NOW ONLY

$1695.00 F.O.B. Nampa, ID

Includes: 110° LNA - Polarizer I - 100' Cable
Wilson MD9 Dish - YM1000 Receiver

Dealerships Available

Antenna is shown with optional LNA cover.

Distributed by

NAMPA SATELLITE SYSTEMS

312 12th Avenue South • Nampa, Idaho 83651
(208) 466-6727
In State Wats 1-800-654-1319 • Out of State Wats 1-800-654-0795

✓ 168

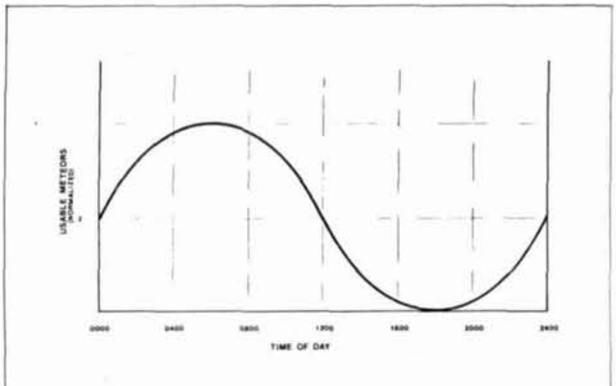


fig. 2. Normalized daily variations in meteor activity.

(NBS) between Cedar Rapids, Iowa, and Sterling, Virginia, a distance of 733 miles (1180 km).[4] A system built by NBS and operated from 1950 to 1952 showed the feasibility of long-range meteor-scatter communication in the 30- to 100-MHz band. Through experience with this system, NBS defined certain operational characteristics of meteor scatter.

Stanford Research Institute (SRI)[5] built the first true meteor-scatter communication system in 1956-57 between Bozeman, Montana, and Palo Alto, California. The SRI system used a two-frequency scheme with a burst rate of 454 bits per second (BPS). A pilot frequency containing no information was continuously transmitted. When the receiving station sensed the pilot signal, it would order the system to begin transfer of data. There were several problems with this approach; mechanical delays in the start-up of data transmission and low receiver sensitivity considerably limited the data transfer rate.

In 1956, the Canadian Defense Research Board[6] began using a system called JANET to conduct experiments over paths of 560 to 745 miles (900 to 1200 km). JANET showed a wide difference in hourly data transfer rates because of daily changes in the number of meteors per unit time and other ionospheric effects, such as sporadic E and aurora. JANET's overall average information rate was 25.5 BPS, which is equivalent to a speed of 38.25 words per minute (WPM).

The National Bureau of Standards resumed meteor communication experiments in 1959, combining JANET technology with some other innovations to attain an overall average data rate of 45 WPM with an error rate of 0.35 percent.[7] The same year, under contract with the United States Air Force, Hughes Aircraft Company developed a system for air-to-ground communication, introducing techniques for improved block transmission and error detection and correction.

In 1965, the North Atlantic Treaty Organization began operating a system called COMET (*CO*mmunication by *ME*teor *T*rails) over a 625-mile (1000-km) path using a 200 watt transmitter and a system for Automatic Repeat Request (ARQ).[8] ARQ is a system of error detection that allows the receiving station to

fig. 3. Approximate data collection coverage of SNOTEL system.

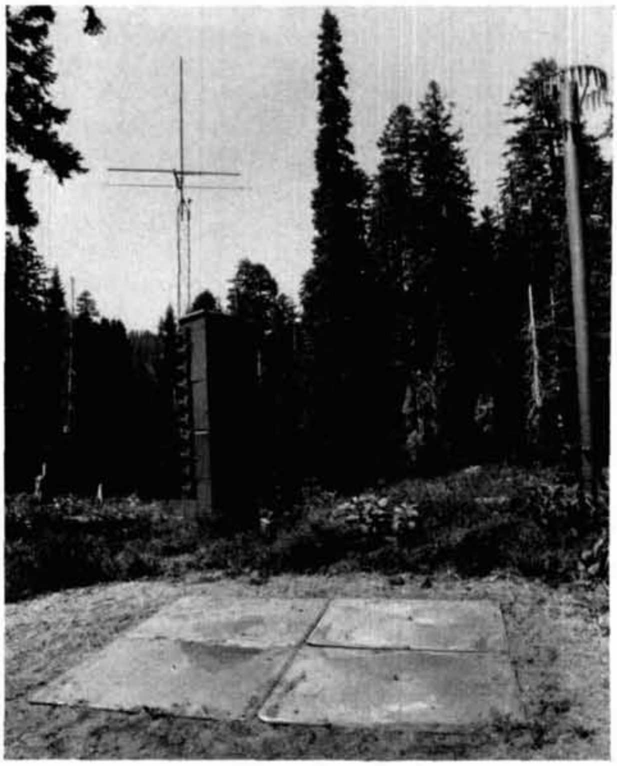


fig. 4. SNOTEL remote site with snow water sensors in foreground.

fig. 5. SNOTEL remote site in winter.

automatically request a repeat of the last information received. COMET achieves a worstcase data rate of 14 WPM and an average of 140 WPM.

largest meteor-scatter link

The Soil Conservation Service of the U.S. Department of Agriculture operates the world's largest meteor-scatter communications data collection system (**fig. 3**) installed over a period of four years (1976-1980), it is a hydrometeorological data collection system called SNOTEL (*SNO*w *TEL*emetry) located in the western United States.

Located in isolated mountain areas, the nearly 500 SNOTEL installations (**figs. 4** and **5**) collect and transmit detailed data on weather and snow conditions, updating information every 15 minutes. The data is used by the Soil Conservation Service for a number of purposes, including forecasting the amount of water available for irrigation, municipal water supplies, and power generation the following spring and summer.

SNOTEL is controlled by a computer in Portland, Oregon; the two master stations in Ogden and Boise (**fig. 6**) can request, receive, and acknowledge data from any of the remote sites, using phase shift keyed transmitters with Henry "4K ULTRA" finals and four phase locked loop-based receivers. Each of the four antennas at the master station is a five-element Yagi directed at a different quadrant of the sky and tipped up 30 degrees to optimize perfomance (**fig. 7**). Currently, the system collects data from a high percentage (typically 90 to 95 percent) of the more than 1015 active channels in the system during a 2-hour nominal polling period each day — a collection of 7000 characters or the equivalent of 1400 five-letter words per hour, and in maximum message lengths of 256 to 512 bits of sensor data.

possible Amateur applications

Current microprocessor technology opens up the field of meteor burst for the Amateur Radio community. An Amateur meteor-scatter system can be constructed using a microprocessor to control the receive and transmit activity. Literally *anything* that can be digitized — pictures, RTTY data — can be transmitted via meteor burst.

The key to an Amateur meteor-burst communication system is a standardized format, bit rate, and an "acknowledge" or ARQ system. Several versions of ARQ system introduced by current meteor-scatter technology are adaptable to Amateur Radio use. Microprocessor technology offers several schemes for developing ARQ systems for error detection and transmission requests.

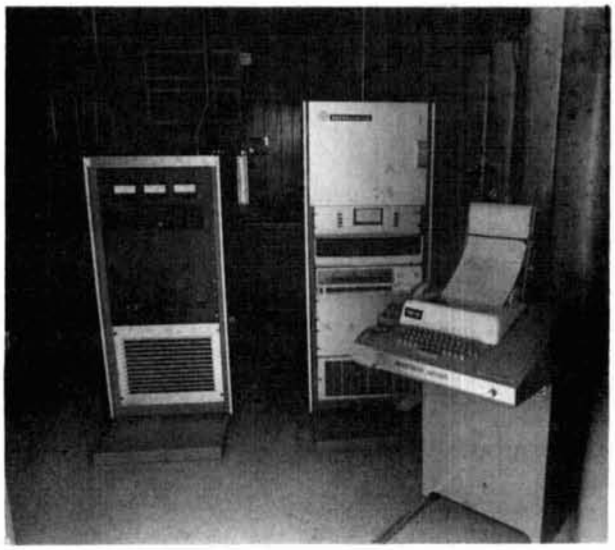


fig. 6. Interior of master station at Boise, Idaho.

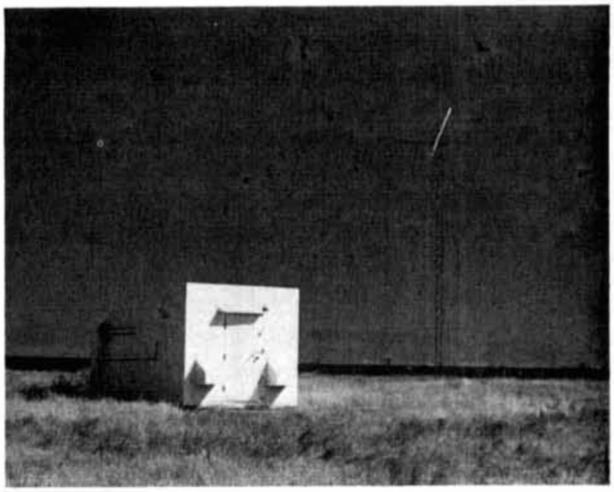


fig. 7. SNOTEL master station located at Boise, Idaho, and one of its four antennas.

A workable format, detailed in **fig. 8**, consists of 16-bit sync train (two 8-bit bytes), 72 words of data (characters), one byte of parity information, and one group number byte. (This is similar to the SNOTEL data stream and is convenient for computer use because of the 72 characters per line.) Inclusion of the group number allows the receiving end of the communications link to request repeat of a single burst or group of bursts. Basically this is a simple extension of the computer-monitored RTTY station that grew out of the Auto-Start-Auto-Answer RTTY station.

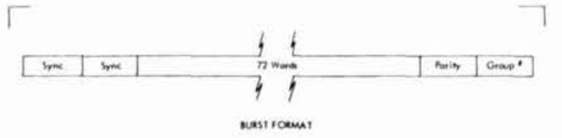


fig. 8. Possible burst format.

conclusion

Almost unlimited opportunity for discovery exists in the field of meteor burst communications. Areas open to Amateur experimentation include antenna design and direction control, error detection and correction techniques, and frequency dependence. Amateurs could take an active role in the improvement of remote control and RTTY systems and in perfecting techniques of data collection and monitoring.

With their access to technology appropriate for use in exploration of the field, Amateur Radio operators enjoy a unique opportunity for innovation and exploration in this expanding field.

references

1. W. Bain, "VHF Propagation by Meteor Trail Ionization," *QST*, May, 1974, page 41.
2. A.M. Skellett, "The Ionizing Effect of Meteors in Relation to RF Propagation," *Proceedings, IRE*, Vol. 20, pages 1933-1940, December, 1932.
3. E.W. Allen, "Reflection of Very High Frequency Radio Waves from Meteoric Ionization," *Proceedings, IRE*, Vol. 36, pages 346-352, March, 1948.
4. D.K. Bailey, R. Bateman, and R.C. Dirby, "Radio Transmission at VHF by Scattering Processes in the Lower Ionosphere," *Proceedings, IRE*, Vol. 43, pages 1118-1230, October 1955.
5. W.R. Vincent, et al., "A Meteor-Burst System for Extended Range VHF Communications," *Proceedings, IRE*, Vol. 45, pages 1963-1970, December, 1957.
6. P.A. Forsyth, et al., "The Principle of JANET — A Meteor-Burst Communication System," *Proceedings, IRE*, Vol. 45, pages 1942-1957, December 1957.
7. R.J. Carpenter, and G.R. Ochs, "The NBS Meteor-Burst Communication System," *Proceedings, IRE*, Vol. 48, pages 263-271, December, 1959.
8. P.J. Bartholome and I.M. Vogt, "COMET — A New Meteor-Burst System Incorporating ARQ and Diversity Reception," *IEEE Transactions on Communications Technology*, Vol. COM — 14, pages 268-278, April, 1966.

ham radio

THE MOST AFFORDABLE REPEATER

ALSO HAS THE MOST IMPRESSIVE PERFORMANCE FEATURES

(AND GIVES THEM TO YOU AS STANDARD EQUIPMENT!)

JUST LOOK AT THESE PRICES!

Band	Kit	Wired/Tested
10M,6M,2M,220	$680	$880
440	$780	$980

Both kit and wired units are complete with all parts, modules, hardware, and crystals.

CALL OR WRITE FOR COMPLETE DETAILS.

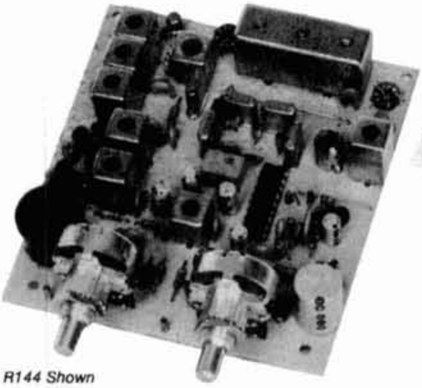
Also available for remote site linking, crossband, and remote base.

FEATURES:

- SENSITIVITY SECOND TO NONE; TYPICALLY 0.15 uV ON VHF, 0.3 uV ON UHF.
- SELECTIVITY THAT CAN'T BE BEAT! BOTH 8 POLE CRYSTAL FILTER & CERAMIC FILTER FOR GREATER THAN 100 dB AT ± 12KHZ. HELICAL RESONATOR FRONT ENDS. SEE R144, R220, AND R451 SPECS IN RECEIVER AD BELOW.
- OTHER GREAT RECEIVER FEATURES: FLUTTER-PROOF SQUELCH, AFC TO COMPENSATE FOR OFF-FREQ TRANSMITTERS, SEPARATE LOCAL SPEAKER AMPLIFIER & CONTROL.
- CLEAN, EASY TUNE TRANSMITTER; UP TO 20 WATTS OUT (UP TO 50W WITH OPTIONAL PA).

HIGH QUALITY MODULES FOR REPEATERS, LINKS, TELEMETRY, ETC.

HIGH-PERFORMANCE RECEIVER MODULES

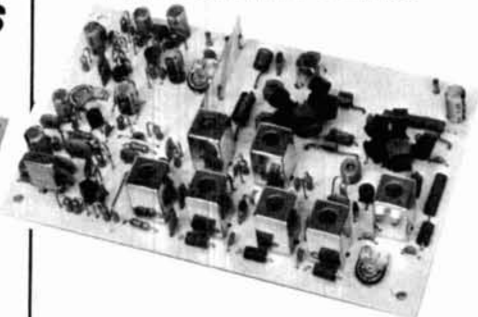


R144 Shown

- **R144/R220 FM RCVRS** for 2M or 220 MHz. 0.15uV sens.; 8 pole xtal filter & ceramic filter in i-f, helical resonator front end for exceptional selectivity, more than −100 dB at ±12 kHz, best available today. Flutter-proof squelch. AFC tracks drifting xmtrs. Xtal oven avail. Kit only $138.
- **R451 FM RCVR** Same but for uhf. Tuned line front end, 0.3 uV sens. Kit only $138.
- **R76 FM RCVR** for 10M, 6M, 2M, 220, or commercial bands. As above, but w/o AFC or hel. res. Kits only $118.
Also avail w/4 pole filter, only $98/kit.
- **R110 VHF AM RECEIVER** kit for VHF aircraft band or ham bands. Only $98.
- **R110-259 SPACE SHUTTLE RECEIVER,** kit only $98.

hamtronics®

TRANSMITTERS

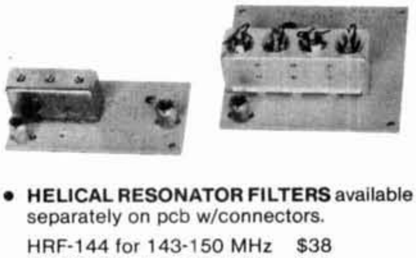


- **T51 VHF FM EXCITER** for 10M, 6M, 2M, 220 MHz or adjacent bands. 2 Watts continuous, up to 2½ W intermittent. $68/kit.

- **T451 UHF FM EXCITER** 2 to 3 Watts on 450 ham band or adjacent freq. Kit only $78.
- **VHF & UHF LINEAR AMPLIFIERS.** Use on either FM or SSB. Power levels from 10 to 45 Watts to go with exciters & xmtg converters. Several models. Kits from $78.
- **A16 RF TIGHT BOX** Deep drawn alum. case with tight cover and no seams. 7 x 8 x 2 inches. Designed especially for repeaters. $20.

ACCESSORIES

- **COR KITS** With Audio mixer, speaker amplifier, tail & time out timers. Kit only $38.
- **CWID KITS** 158 bits, field programmable, clean audio, rugged TTL logic. Kit only $68.
- **DTMF DECODER/CONTROLLER KITS.** Control 2 separate on/off functions with touchtones®, e.g., repeater and autopatch. Use with main or aux. receiver or with Autopatch. Only $90
- **AUTOPATCH KITS.** Provide repeater autopatch, reverse patch, phone line remote control of repeater, secondary control via repeater receiver. Many other features. Only $90. Requires DTMF Module.



- **HELICAL RESONATOR FILTERS** available separately on pcb w/connectors.

HRF-144	for 143-150 MHz	$38
HRF-220	for 213-233 MHz	$38
HRF-432	for 420-450 MHz	$48

NEW LOW-NOISE PREAMPS

New low-noise microwave transistors make **preamps** in the 0.9 to 1.0 dB noise figure **range possible** without the fragility and power supply problems of gas-fet's. Units furnished **wired and** tuned to ham band. Can be easily **retuned** to nearby freq.

Models LNA( ), P30, and P432 shown

Model	Tunable Freq Range	Noise Figure	Gain	Price
LNA 28	20-40	0.9 dB	20 dB	$39
LNA 50	40-70	0.9 dB	20 dB	$39
LNA 144	120-180	1.0 dB	18 dB	$39
LNA 220	180-250	1.0 dB	17 dB	$39
LNA 432	380-470	1.0 dB	18 dB	$45
LNA 800	470-960	1.2dB	15 dB	$45

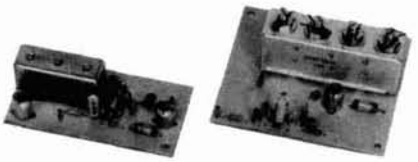
ECONOMY PREAMPS

Our traditional preamps, proven in years of service. Over 20,000 in use throughout the world. Tuneable over narrow range. Specify exact freq. band needed. Gain 16-20 dB. NF = 2 dB or less. VHF units available 27 to 300 MHz. UHF units available 300 to 650 MHz.

- P30K, VHF Kit less case $18
- P30W, VHF Wired/Tested $33
- P432K, UHF Kit less case $21
- P432W, UHF Wired/Tested $36

P432 also available in broadband version to cover 20-650 MHz without tuning. Same price as P432; add "B" to model #.

HELICAL RESONATOR PREAMPS



Our lab has developed a new line of low-noise receiver preamps with helical resonator filters built in. The combination of a low noise amplifier similar to the LNA series and the sharp selectivity of a 3 or 4 section helical resonator provides increased sensitivity while reducing intermod and cross-band interference in critical applications. See selectivity curves at right. Noise figure = 1 to 1.2 dB. Gain = 12 to 15 dB.

Model	Tuning Range	Price
HRA-144	143-150 MHz	$49
HRA-220	213-233 MHz	$49
HRA-432	420-450 MHz	$59
HRA-( )	150-174MHz	$69
HRA-( )	450-470 MHz	$79

RECEIVING CONVERTERS

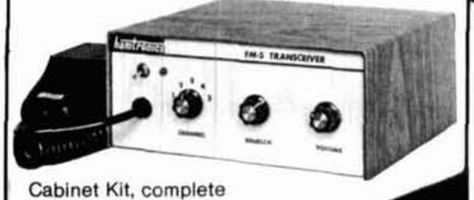
Models to cover every practical rf & if range to listen to SSB, FM, ATV, etc. NF = 2 dB or less.

	Antenna Input Range	Receiver Output
VHF MODELS	28-32	144-148
Kit with Case $49	50-52	28-30
Less Case $39	50-54	144-148
Wired $69	144-146	28-30
	145-147	28-30
	144-144.4	27-27.4
	146-148	28-30
	144-148	50-54
	220-222	28-30
	220-224	144-148
	222-226	144-148
	220-224	50-54
	222-224	28-30
UHF MODELS	432-434	28-30
Kit with Case $59	435-437	28-30
Less Case $49	432-436	144-148
Wired $75	432-436	50-54
	439.25	61.25

SCANNER CONVERTERS Copy 72-76, 135-144, 240-270, 400-420, or 806-894 MHz bands on any scanner. Wired/tested Only $88.

SAVE A BUNDLE ON VHF FM TRANSCEIVERS!

FM-5 PC Board Kit – **ONLY $178** complete with controls, heatsink, etc. 10 Watts, 5 Channels, for 2M or 220 MHz.



Cabinet Kit, complete with speaker, knobs, connectors, hardware. Only $60.

REPEAT OF A SELLOUT!

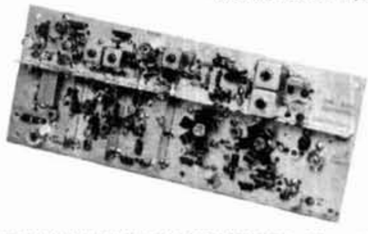
While supply lasts, get $60 cabinet kit free when you buy an FM-5 Transceiver kit. Where else can you get a complete transceiver for only $178

TRANSMIT CONVERTERS

For SSB, CW, ATV, FM, etc. Why pay big bucks for a multi mode rig for each band? Can be linked with receive converters for transceive. 2 Watts output vhf, 1 Watt uhf.

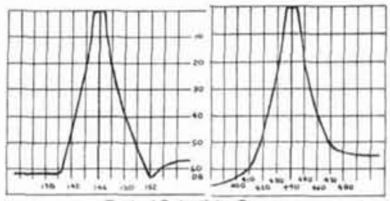
	Exciter Input Range	Antenna Output
For VHF,	28-30	144-146
Model XV2	28-29	145-146
Kit $79	28-30	50-52
Wired $149	27-27.4	144-144.4
(Specify band)	28-30	220-222*
	50-54	220-224
	144-146	50-52
	50-54	144-148
	144-146	28-30
For UHF,	28-30	432-434
Model XV4	28-30	435-437
Kit $99	50-54	432-436
Wired $169	61.25	439.25
	144-148	432-436*

*Add $20 for 2M input



VHF & UHF LINEAR AMPLIFIERS. Use with above. Power levels from 10 to 45 Watts. Several models, kits from $78.

LOOK AT THESE ATTRACTIVE CURVES!



Typical Selectivity Curves of Receivers and Helical Resonators.

IMPORTANT REASONS WHY YOU SHOULD BUY FROM THE VALUE LEADER:

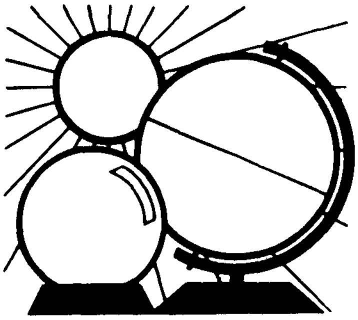
1. *Largest selection of vhf and uhf kits in the world.*
2. *Exceptional quality and low prices due to large volume.*
3. *Fast delivery; most kits shipped same day.*
4. *Complete, professional instruction manuals.*
5. *Prompt factory service available and free phone consultation.*
6. *In business 21 years.*
7. *Sell more repeater modules than all other mfrs. and have for years. Can give quality features for much lower cost.*

- **Call or Write for FREE CATALOG**
- **(Send $1.00 or 4 IRC'c for overseas mailing)**
- **Order by phone or mail ● Add $3 S & H per order**

(Electronic answering service evenings & weekends) Use VISA, MASTERCARD, Check, or UPS COD.

hamtronics, inc.

65-C MOUL RD. • HILTON NY 14468
Phone: 716-392-9430
Hamtronics ® is a registered trademark



DX FORECASTER

Garth Stonehocker, K0RYW

last-minute forecast

Excellent DX conditions on the higher frequency bands (10-30 meters) are expected during the first and second weeks of the month due to a probable increased solar flux. A recurrent disturbed period is also possible around February 4, which should result in better transequatorial openings. Check with WWV's geophysical announcement at 18 minutes after each hour for confirmation of the high solar flux and geomagnetic A values.

Other periods of disturbance may be on the 14th and from the 22nd through the 28th. The lower bands should be very good all month and excellent during low solar flux periods in the third week of the month. Look for DX openings to unusual *east-west* locations during the disturbed days.

No significant meteor showers occur during February. The full moon and lunar perigee are on the 17th.

low band DX

Since publication of the nighttime bands in the propagation chart was begun, have you noticed how high those bands are, even at their diurnal minimum? DX stands for long distance contacts; even the shortest DX path, Europe, is 3800 miles (6200 km) from the East Coast. South America, Japan, and the Far East are approximately 6200 miles (10,000 km), while Antarctica and Australia are 9000 miles (14,600 km) and 9900 miles (16,000 km), respectively. The highest usable bands are related to the maximum usable frequencies (MUF) for that path. The longer DX paths are to the south across the equator where minimum MUFs are around 14-15 MHz now and will decrease by 3 MHz when the sunspot number drops to 16 (or the radio flux to 75 units). The other DX paths are in mid to high latitudes where MUFs are lower and paths are shorter, giving minimum MUFs of only 8-9 MHz. These will decrease by 2 MHz at the sunspot cycle minimum.

These numbers are based on monthly median (January) data. The daily solar flux factors from last month's *DX forecaster* can be used to forecast several days ahead. The *minimum* MUF is inversely related to the daily flux, decreasing with an increasing change in radio flux. Geomagnetic disturbances will also affect these minimum MUFs by 5 to 10 percent — the high latitude paths negatively and transequatorial paths positively.

Interestingly, even at sunspot minimum, 40 meters will be open to Europe, Japan, and the Far East and 30 meters on transequatorial paths. If you work 80 meters and 160 meters, they will be 50 percent and 75 percent below the MUF even on the short-northern paths. This doesn't mean they won't work; we know they do.

band-by-band summary

Ten and fifteen meters will be open for worldwide DX communication from sunrise until after sunset during the twenty-seven day solar flux maximums. Skip of 2500 miles (4000 km) (or multiples) is possible, and will follow the sun across the earth.

Twenty meters will be open to some area of the world for the entire twenty-four hour period on many days of the month. The band should peak in all directions just after local sunrise, and again toward the east and south during late evening hours. During hours of darkness the band will peak toward the west in an arc from southwest through northwest, encompassing Pacific areas.

Thirty meters is a daytime and nighttime band. The day portion should be like 20 meters except in that signal strengths may decrease during midday on days having high solar flux values. This band will also be useful well into the night and often through the night. Once again exceptions to this are on nights that follow very high solar flux value days. The problem time is usually the hour or so before dawn (diurnal MUF minimum). The workable distance may be expected to be greater than 80 DX at night and less than 20 during the day.

Forty and eighty meters will be the most usable nighttime DX bands. Most areas of the world will be workable from dusk until sunrise. Hops shorten on these bands to about 2000 miles for 40 meters and 1500 miles for 80 meters, but the number of hops can increase because signal absorption in the ionosphere's D-region is low during the night. The path follows the direction of darkness across the earth, similar to the way in which the higher bands follow the sun.

One-sixty meters will be similar to 80 meters, providing good working conditions for enthusiastic DXers who like to work nighttime and early morning hours, especially at local dawn.

ham radio

FEBRUARY

WESTERN USA

GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	
PST	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	
ASIA FAR EAST	30	30	30	30	40	40	40	40	40	30	30	30	30	30	20	20	20	20	20	20	20	20	20	20	N
EUROPE	20	20	20	20	20	20	20	20	20	30	30	40	40	40	30	30	30	30	30	30	30	20	20	20	NE
S. AFRICA	15	15	10	10	10	10	15	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	15	15	E
S. AMERICA	10	10	10	15	15	15	15	15	15	20	20	20	20	20	20	20	15	15	10	10	10	10	10	10	SE
ANTARCTICA	15	15	15	15	15	15	15	15	15	20	20	20	20	20	20	15	15	15	15	15	15	15	15	15	S
NEW ZEALAND	10	10	10	10	15	15	15	15	20	20	20	20	20	15	15	15	10	10	10	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	15	15	15	15	20	20	20	20	20	20	20	15	15	15	10	10	10	10	10	10	10	W
JAPAN	20	20	20	20	20	20	30	30	40	40	30	30	30	30	30	20	20	20	20	20*	20	20	20	20	NW

MID USA

MST	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	
ASIA FAR EAST	40	30	30	30	30	30	30	20	20	20	20	20	20	30	30	30	30	30	30	30	30	30	30	30	N
EUROPE	20	20	20	20	20	20	20	20	20	30	30	30	40	40	40	30	30	30	30	30	30	20	20	20	NE
S. AFRICA	15	15	10	10	10	10	10	15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	15	E
S. AMERICA	10	10	10	10	10	10	15	15	15	15	20	20	20	20	20	20	15	15	15	15	10	10	10	10	SE
ANTARCTICA	15	15	15	15	15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	15	15	15	15	15	S
NEW ZEALAND	10	10	10	10	15	15	15	15	20	20	20	20	20	20	15	15	15	10	10	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	15	15	15	15	20	20	20	20	20	20	20	20	15	15	15	10	10	10	10	10	10	W
JAPAN	20	20	20	20	20	30	30	40	40	40	40	30	30	30	30	30	20	20	20	20	20	20	20	20	NW
CST	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	

EASTERN USA

EST	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	
ASIA FAR EAST	40	30	30	30	20	20	20	20	20	20	20	20	20	30	30	30	30	30	30	30	30	30	30	30	N
EUROPE	20	20	20	20	20	20	20	20	20	30	30	30	40	40	40	30	30	30	30	30	30	20	20	20	NE
S. AFRICA	15	15	10	10	10	10	10	10	15*	15	15	15	20	20	20	20	20	20	20	15	15	15	15	15*	E
CARIBBEAN S. AMERICA	15	15	10	10	10	15*	15	15	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	15	SE
ANTARCTICA	15	15	15	15	15	15	15	15	15	15	20	20	20	20	20	20	15	15	15	15	15	15	15	15	S
NEW ZEALAND	10	10	10	10	10	15	15	20	20	20	20	20	20	20	20	15	15	15	10	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	10	15	15	15	20	20	20	20	20	20	20	20	20	15	15	15	10	10	10	10	10	W
JAPAN	20	20	20	20	20	30	30	40	40	40	40	40	30	30	30	30	20	20	20	20	20	20	20	20	NW

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides the MUF during 'normal' hours.
*Look at next **higher** band for possible openings.

hy-gain®

NEW! ONE GREAT MICROPHONE IN FOUR FAVORITE FLAVORS

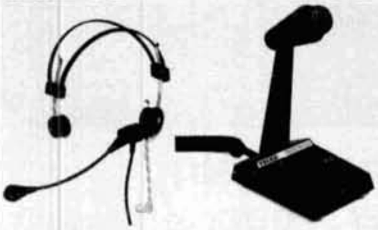
Our finest electret transducer suspended in a housing accoustically engineered for optimum voice communications. Improved audio from any voice—more punch and great to hear. Selectable Hi/Lo Z. Universal! Battery powered FET Preamp delivers "Heavy Duty" Output—will fully modulate any rig. Immune to RFI.

PRO-COM 250 **PRO-COM 350**

PRO-COM 250
- Built to last.
- Super soft earcup and head cushions.
- Noise cancelling mic. superb VOX action.
- Isolates you from surrounding noise and vice versa.
- Swing the boom up and you have a great pair of earphones for CW.

PRO-COM 350
- The ultimate in comfort.
- Noise cancelling mic. great VOX action using built-in earphone or station loudspeaker.
- Use headband supplied or clip to eyeglass bow.

PRO-COM 352-IC **PRO-COM 400**



PRO-COM 352-IC
- Special Pro-Com 350 with connectors to plug into ICOM Ham Hand Helds.
- Uses DC from transceiver.
- PTT switch with belt clip.

PRO-COM 400
- First notable advance since the dynamic transducer. A new standard of great sound.
- Die cast metal—you won't tip this one over.
- No "Handling" noise.
- Switching for VOX operation or Manual PTT with lock-on.
- Shielded hi-flex cord.

FS-1 Foot Switch
HS-1 Hand Switch In line push-to-talk switch

See them at your favorite Telex/Hy-Gain Distributor

TELEX. hy-gain

TELEX COMMUNICATIONS, INC.

9600 Aldrich Ave. So., Minneapolis, MN 55420 U.S.A.
Europe: Le Bonaparte—Office 711, Centre Affaires Paris-Nord, 93153 Le Blanc-Mesnil, France.

10GHz GUNNPLEXER transceiver

- Complete ready to use 10 GHz fm voice/cw transceiver • 10 mW power output • Typical frequency coverage 10.235-10.295 GHz • Full duplex operation • Internal Gunnplexer for portable operation • Gunnplexer removable for tower mounting in fixed location service — three shielded cables required for interconnection • Powered by 13 volts dc nominal at 250 mA • 30 MHz i-f • 10-turn potentiometer controlled VCO tuning • 220 kHz ceramic i-f filter • Extra diode switched filter position for optional filter • Dual polarity afc • Rugged two-tone grey enclosure • Full one year warranty • $389.95 with 10 mW Gunnplexer • $269.95 without Gunnplexer

Advanced Receiver Research

Postpaid for U.S. and Canada. CT Residents add 7-½% sales tax. C.O.D. orders add $2.00. Air mail to foreign countries add 10%

Box 1242 • Burlington CT 06013 • 203 582-9409

MasterCard VISA

✓ 104

AMAZING SCIENTIFIC and ELECTRONIC DEVICES

LASER DEVICES
- LC5 BURNING CUTTING CO2 LASER $15.00
- RUB3 RUBY LASER RAY PISTOL 15.00
- LRG3 IR LASER RIFLE/PISTOL 10.00
- LGU3 VISIBLE RED LASER RIFLE 10.00
- LHP/LLD LASER LIGHT XMTR/RCVR SYS 10.00
- LHC2 BEGINNER simulated VISIBLE LASER 5.00

SCIENTIFIC & ELECT
- TCL3 SOLID STATE TESLA COIL 35KV 6.00
- BTC3 25C THOUSAND VOLT TESLA COIL 9.00
- BTC5 1.5 MILLION VOLT TESLA COIL 15.00
- HVM3 125 THOUSAND VOLT DC SUPPLY 8.00
- IOG3 ION RAY FORCE FIELD GUN 8.00
- HEG1 MILLION WATT 500 JOULE SOURCE 10.00

ULTRASONIC ACOUSTICAL
- PPF1 PHASOR PAIN FIELD GENERATOR 15.00
- PSP3 PHASOR SHOCK WAVE PISTOL 7.00
- IPG5 POCKET PAIN FIELD GENERATOR 7.00
- RAT2 RAT AND PEST ELIMINATOR 6.00
- HT9 HIGH FREQ. LISTENING DEVICE 8.00

SECURITY & PROTECTION
- DEVI DEVASTATING DEVICES 10.00
- PPG1 PHASOR PROPERTY GUARD 15.00
- MFT1 MINI VOICE XMTR 2-3 MILE 7.00
- INF1 INFINITY TRANSMITTER 15.00
- PSW3 PHASOR BURNING STUN WAND 8.00
- PG1 PARALYZING WAND 10.00

WE STOCK ALL PARTS NECESSARY FOR CONSTRUCTION OF THE ABOVE PROJECTS

• **CATALOG** CONTAINING **HUNDREDS** MORE OF ALL **NEW AMAZING** and **FASCINATING** PLANS. EASY TO BUILD KITS AND ASSEMBLED ITEMS $1.00. CATALOG INCLUDED **FREE** WITH ANY OF THE ABOVE PROJECT PLANS. SEND CASH, CHECK, MO, VISA, MC TO:

INFORMATION UNLIMITED

P.O. BOX 716, DEPT. HR AMHERST, NH 03031

✓ 151

Have a name—but need the Call Sign?

Traveling—and want to meet local Hams?

NOW AVAILABLE—

1983-1984 Amateur Radio

NAME INDEX

By Name and Call.

1983-1984 Amateur Radio

GEOGRAPHICAL INDEX

By State, City, Street No. and Call.

No frills directories of over 435,000 U.S. Radio Amateurs. 8½x11, easy to read format. Companion directories to the 1983-1984

AMATEUR RADIO

CALL DIRECTORY *U.S. Listing*

- **NAME INDEX—$25.00**
- **GEOGRAPHICAL INDEX—$25.00**
- **CALL DIRECTORY—$14.95**

Add $3.00 shipping to all orders.

Dealer/Club inquiries welcome.
Send your order-enclosing check or money order in U.S. dollars to:

Buckmaster Publishing
Whitehall
Mineral, VA 23117 U.S.A.
(703) 894-5777

✓ 117

PCS-4000
2-m FM Transceiver

EXCLUSIVE 1 YEAR LIMITED WARRANTY! *COMPARE!*

THE 4000 SERIES

PCS-4300 70-cm FM Transceiver

PCS-4500 6-m FM Transceiver

PCS-4800 10-m FM Transceiver

WINTER SALE

PLEASE CALL FOR SPECIAL PRICE

PCS-300
2m Handheld
FM Transceiver
142-149.995 MHz

106

- **WIDE FREQUENCY COVERAGE:** PCS-4000 covers 142.000-149.995 MHz in selectable steps of 5 or 10 kHz. PCS-4200 covers 220.000-224.995 MHz in selectable steps of 5 or 20 kHz. PCS-4300 covers 440.000-449.995 MHz in selectable steps of 5 or 25 kHz. PCS-4500 covers 50.000-53.995 MHz in selectable steps of 5 or 10 kHz. PCS-4800 covers 28.000-29.990 MHz in selectable steps of 10 or 20 kHz.
- **CAP/MARS BUILT IN:** PCS-4000 includes coverage of CAP and MARS frequencies.
- **TINY SIZE:** Only 2"H × 5.5"W × 6.8"D. COMPARE!
- **MICROCOMPUTER CONTROL:** At the forefront of technology!
- **UP TO 8 NONSTANDARD SPLITS:** Ultimate versatility. COMPARE!
- **16-CHANNEL MEMORY IN TWO 8-CHANNEL BANKS:** Retains frequency and standard simplex or plus/minus offsets. Standard offsets are 600 kHz for PCS-4000, 1.6 MHz for PCS-4200, 5 MHz for PCS-4300, 1 MHz for PCS-4500, and 100 KHz for PCS-4800.
- **DUAL MEMORY SCAN:** Scan memory banks either separately or together. COMPARE!
- **TWO RANGES OF PROGRAMMABLE BAND SCANNING:** Limits are quickly reset. Scan the two segments either separately or together. COMPARE!
- **FREE AND VACANT SCAN MODES:** Free scanning stops 5 seconds on a busy channel; auto-resume can be overridden if desired. Vacant scanning stops on unoccupied frequencies.
- **DISCRIMINATOR SCAN CENTERING (AZDEN EXCLUSIVE PATENT):** Always stops on frequency.
- **TWO PRIORITY MEMORIES:** Either may be instantly recalled at any time. COMPARE!
- **NICAD MEMORY BACKUP:** Never lose the programmed channels!
- **FREQUENCY REVERSE:** The touch of a single button inverts the transmit and receive frequencies, no matter what the offset.
- **ILLUMINATED KEYBOARD WITH ACQUISITION TONE:** Unparalleled ease of operation.
- **BRIGHT GREEN LED FREQUENCY DISPLAY:** Easily visible, even in direct sunlight.
- **DIGITAL S/RF METER:** Shows incoming signal strength and relative power output.
- **BUSY-CHANNEL AND TRANSMIT INDICATORS:** Bright LEDs show when a channel is busy and when you are transmitting.
- **FULL 16-KEY TOUCHTONE® PAD:** Keyboard functions as autopatch when transmitting (except in PCS-4800).
- **PL TONE:** Optional PL tone unit allows access to private-line repeaters. Deviation and tone frequency are fully adjustable.
- **TRUE FM:** Not phase modulation. Unsurpassed intelligibility and audio fidelity.
- **HIGH/LOW POWER OUTPUT:** 25 or 5 watts selectable in PCS-4000; 10 or 1 watt selectable in PCS-4200, PCS-4300, PCS-4500, and PCS-4800. Transmitter power is fully adjustable.
- **SUPERIOR RECEIVER:** Sensitivity is 0.2 uV or better for 20-dB quieting. Circuits are designed and manufactured to rigorous specifications for exceptional performance, second to none. COMPARE!
- **REMOTE-CONTROL MICROPHONE:** Memory A-1 call, up/down manual scan, and memory address functions may be performed without touching the front panel! COMPARE!
- **OTHER FEATURES:** Dynamic microphone, rugged built-in speaker, mobile mounting bracket, remote speaker jack, and all cords, plugs, fuses, and hardware are included.
- **ACCESSORIES:** CS-7R 7-amp ac power supply, CS-4.5R 4.5-amp ac power supply, CS-AS remote speaker, and Communications Specialists SS-32 PL tone module.
- **ONE YEAR LIMITED WARRANTY!**

EXCLUSIVE DISTRIBUTOR: DEALER INQUIRIES INVITED

AMATEUR-WHOLESALE ELECTRONICS **TOLL FREE...800-327-3102**

8817 S.W. 129th Terrace, Miami, Florida 33176 Telephone (305) 233-3631 Telex: 80-3356

VISA MasterCard

MANUFACTURER

JPC AZDEN **JAPAN PIEZO CO., LTD.**

1-12-17 Kamirenjaku, Mitaka, Tokyo, 181 Japan. Telex: 781-2822452

EMI/RFI shielding: new techniques
part 2

Techniques and materials that reduce EMI

Part 1 of this two-part article served as a basic overview by identifying the problem of EMI/RFI, citing examples of its adverse effects, and providing a general discussion of EMI shielding effectiveness (SE). In one form or another, each of these various schemes involved plastics. This more detailed, more technical article examines methods of testing SE that employ RF techniques familiar to most hams.

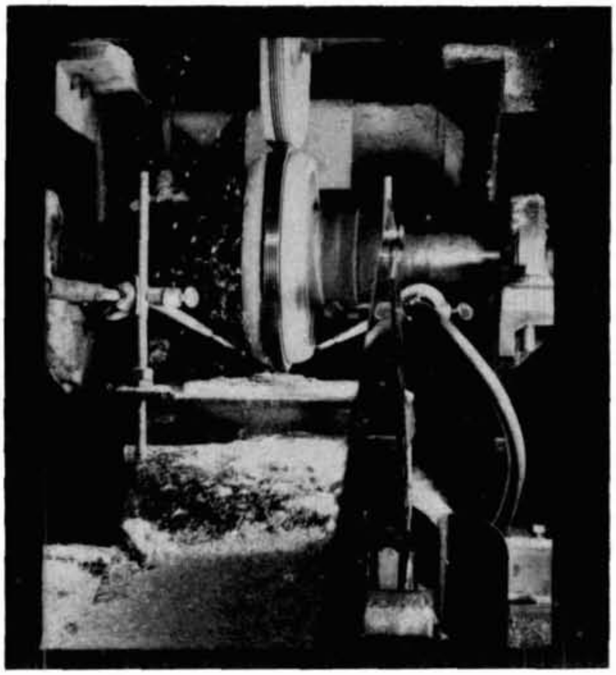


fig. 1. The generation of aluminum flakes.

Before examining SE and its testing, let's first examine the process of fabricating plastics in a manner that renders them effective for EMI shielding and containment, yet is economical enough to allow plastic enclosures to be used instead of metal ones.

EMI and plastics

The FCC tries to stringently enforce EMI emission standards that apply to electronic equipment. The pressures of foreign competition, however, demand that American manufacturers develop innovative cost-cutting manufacturing techniques such as using EMI-proof plastic enclosures instead of metal enclosures. But there are other ways than the use of enclosures to obtain or shield electronic devices from EMI/RFI; we can use metallic tape with adhesive backs (the adhesive is a plastic), neoprene and elastomer gaskets (both plastics), or sprays and paints in conjunction with plastics. In fact, plastics are so common that we sometimes overlook them, and often fail to fully appreciate or understand their versatility.

In order to better understand how plastics are used in potting and casting, in PC board conformal coating, in insulation, high frequency connectors and a myriad of other applications, let's begin by looking at materials used for shielding.

materials for shielding

Most EMI shielding processes in use today have disadvantages: precious metal powders are expensive; conductive carbon comes in but one color — black — zinc metallic sprays can lose adhesion, with small metal flakes falling onto PC boards and shorting out components; and paints are subject to abrasion and subsequent delamination when put through temperature extremes. What is the solution to the problem? The answer may be a new technique of utilizing structured fillers.

By Vaughn D. Martin, 114 Lost Meadows, Cibolo, Texas 78108

Graphite fillers. With higher conductivity and better reinforcement characteristics than carbon blacks, graphite fillers look promising. Radar chaff, for example, originally developed to resonate at radar frequencies and to produce "phantom" targets for anti-aircraft batteries, has been successfully introduced into these types of composite plastics.

Impregnation of aluminum flakes into plastic is a relatively new process. A spinning wheel throws off flakes of molten aluminum alloy (see **fig. 1**); these flakes, with a tightly controlled aspect ratio (length-to-thickness ratio), are then deposited into a resin which causes them to become oriented in the direction of the flow of the resin. You have no doubt seen fingerlings or small minnows in schools orient themselves upstream in line with the flow of water; these flakes do the same in the resin. This is important because molding or extrusion processes require this. If all flakes are not oriented in the same direction, they experience lateral force and breakage occurs, with a subsequent reduction in their shielding effectiveness.

Typically, aluminum-impregnated plastics contain 18 to 22 percent flakes by volume because electrical conductivity depends not on the weight ratio of the flakes with their resin "holder," but on the volume ratio of flakes to resin. This means that a low-density polymer like polypropylene would need 46 percent weight, while a high-density polymer like PVC would require only 37 percent flakes to achieve the same 22 percent volume ratio.

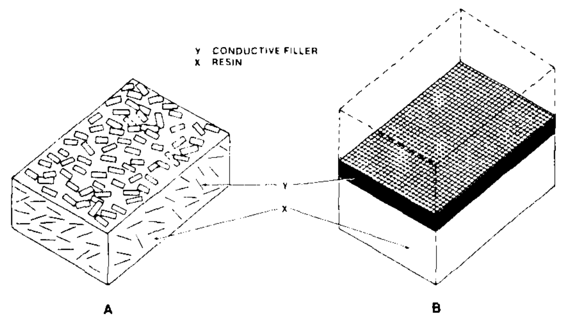


fig. 2. Composite of conductive particles suspended in an insulating matrix.

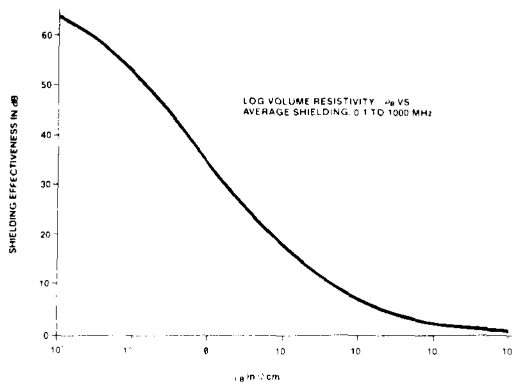


fig. 3. Graph of averaged surface and volume resistivity.

the acid test

To date, most testing techniques have been contrived to test conductors or pieces of pure conductive materials. But now, the purely resistive properties of a substance like straight wire no longer exist; the combining of metals with plastics has caused networks to result with both inductive and capacitive reactances.

In **fig. 2**, note that if probes were to pass through the insert on the left at precisely the right spot, they could miss the conductive particles, completely giving a totally insulative test result. But insertion as a layer in the material to the right with its insulating matrix (checkerboard) results in a more meaningful measurement. (Two test methods of determining surface and volume resistivity can be averaged to determine shielding effectiveness form 0.1 to 1000 MHz by the graph in **fig. 3**).

To evaluate how well material acts as a shield, let's first recognize that a pure conductive metal performs its shielding effectiveness by an almost 100 percent *reflection of radiation*, whereas a conductive-composite product reflects about 80 percent of radiation and absorbs 20 percent. Mathematically, the shielding effectiveness, expressed in dB, (SE) + R + A or the sum of the energy *A*bsorbed and *R*adiated. In actual practice, there is another term, B, added to A and R, but this term describing internal multiple reflections is usually ignored for materials with greater than 10 dB of SE. This would include just about all materials that are even remotely considered to be shielding elements.

test and measurement systems

There are essentially three methods of measurement: the free-space method, which is impractical at lower frequencies; the shielded box method; and the transmission line technique. The shielded box technique, shown in **fig. 4**, is the most popular. This rectangular metal box, made with thick walls and electrically tight seams in the walls, has a transmitting antenna inside it and a sample port (opening) in one wall for radiation emitted through the port. If the specimen to be tested is placed over the port or hole, and the radiated power P_2 measured against the open power level P_1, SE can be determined by:

$$SE = 10 \log \frac{P_1}{P_2} \text{ (in dB)}$$

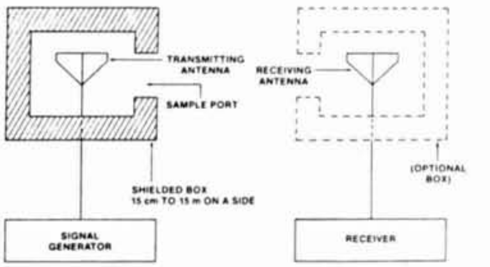


fig. 4. Pictorial illustration of a shielded test chamber.

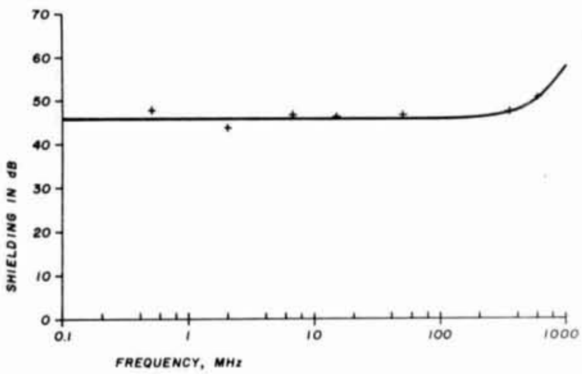


fig. 5. Graph of the dynamic range possible with the coaxial line test technique.

This method of testing has some problems. If there is an edge in the chamber that approaches the wavelength of radiation, resonance can occur with ensuing standing waves between the antennas inside and the chamber's walls. Also, at lower frequencies, the dynamic range is limited to approximately 50 dB because of the energy that can pass through the small sample port at those wavelengths. It is likely that no two boxes would report the same results for a given sample.

The coaxial transmission line technique has no inherent problems associated with it because this method is not frequency-sensitive. (Note that there are no seams in this canister-shaped specimen holder.) Dynamic range, (**fig. 5**), is a function of the generator and the sensitivity of the receiver. Unlike the shielded box, which suffered from the wavelength-to-specimen size ratio changing the chamber's own inherent impedance, this problem does not exist with the transmission line technique.

This method (the TEM or transverse electromagnetic cell) yields reflected, transmitted and absorbed data by reflection coefficient measurements, which allows the designer of the system to optimize reflection. This is ideal for waveguides or parabolic antennas in which the wave is to be redirected.

The main advantage of this measurement technique is the uniformity of repeated test results. The TEM, (**fig. 6**), allows absolute verification to be made that the reflection and transmission ratios in a 50-ohm line are the same as those theoretically obtained in free space on a panel infinite in extent in the plane perpendicular to the incident energy. The dimensions of a 50-ohm line are such that the ratio of the impedance presented by a test specimen transverse to the direction of propagation, to that presented to the free space wave by the same material, is 0.13. This is the exact ratio of 50/377 (the two characteristic impedances).

Electromagnetic fields near an oscillating dipole antenna have a wave impedance as a function of 1/d, where d is the distance between the source and receiver. This is true when the distance to the dipole antenna is very small in comparison to the wave-

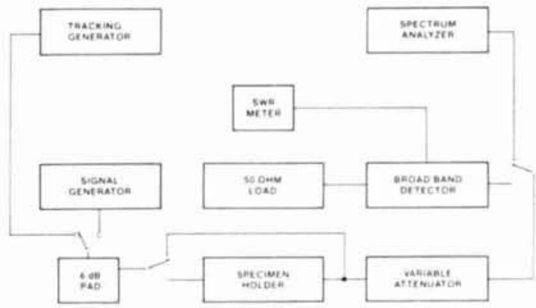


fig. 6. A block diagram of the coaxial line test technique (TEM Cell).

fig. 7. The TEM (Transverse Electromagnetic Cell) test method in operation.

namic range can be obtained with standard coaxial cables.

Analysis of test results shows how "flat" the test results are from 0.1 to 1,000 MHz, (**figs. 8** and **9**). The difference between measured and predicted results is due to the uncertainty of measurement of the conductivity of the composite plastic, as previously discussed. **Fig. 8** shows a specimen of 20 percent weight piece of Transmet™* series 100 conductivity modifiers in a polyester resin. The methods used in testing were the shielded box method, using a 6.25 foot (2 meter) cubic box in a 31 × 15.5 × 10 foot (10 × 5 × 3 meter) shielded room; the last method was the transmission line technique. **Figs. 10** and **11** show various plastics test results for *SE*.

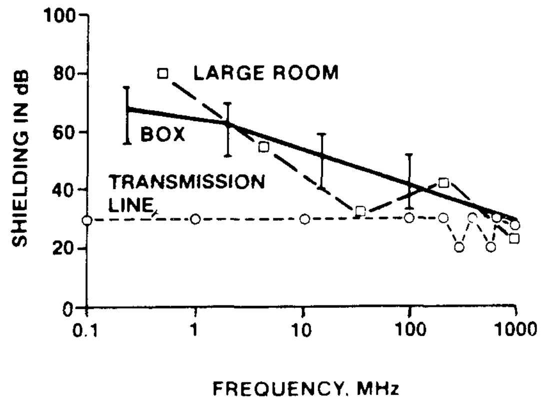


fig. 8. Large room/shielded box/transmission line technique test results.

length and precisely why, at lower frequencies, within a shielded box, the impedance changes with frequency. (We will note some data shortly that graphically reveal this fallacy.) Likewise, as the wave impedance and reflection coefficient increase as frequency decreases, a false indication of an enhanced *SE* results as the frequency decreases.

The coaxial transmission line technique is an insertion-loss measurement technique using a substitution method (see **fig. 7**). The measurements can be made at specific frequencies (the point-to-point mode) using a modulated signal generator, crystal detector, and tuned amplifier (SWR). The other method employs sweeping a band of frequencies with a tracking generator and a spectrum analyzer used as a receiver. The advantage of this point-by-point method is that other information, such as reflection coefficient data, can be taken in this mode; the sweeping mode has the advantage of taking *SE* data at all points, but without the luxury of allowing observation of reflection coefficients.

In the sweeping mode, the signal generator is replaced by a tracking generator and the variable attenuator removed, because the attenuator in the analyzer is used instead. The spectrum analyzer presents the response over the whole bandwidth in a single curve. However, for determination of *SE*, two responses are taken, one with and one without the specimen in the holder. The *SE* is the difference between these two curves.

The dynamic range of this measurement technique is determined by three things: the power level of the signal generator, the sensitivity of the receiver, and the degree of shielding of the equipment and the connecting transmission lines. For example, if a one-watt signal generator with a detector such as an HP415 standing-wave meter are used, an 80-dB dy-

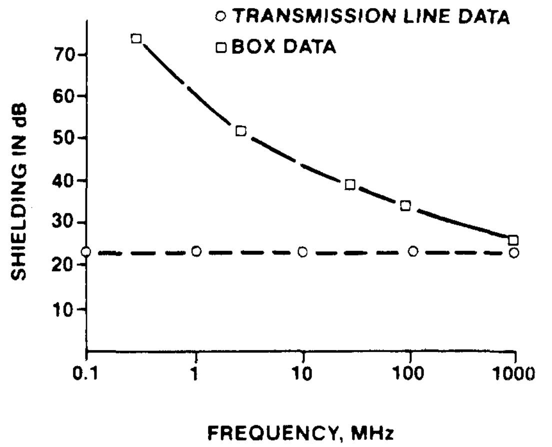


fig. 9. Transmission line technique vs. shielded box test results.

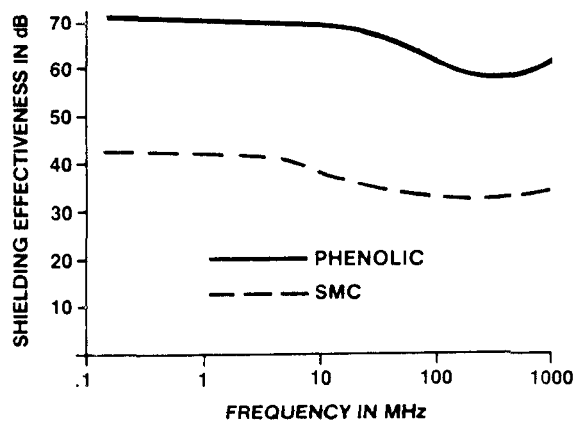


fig. 10. 30-dB SE gained from treated vs. untreated specimens of phenolics.

*The Transmet Corporation, Columbus, Ohio

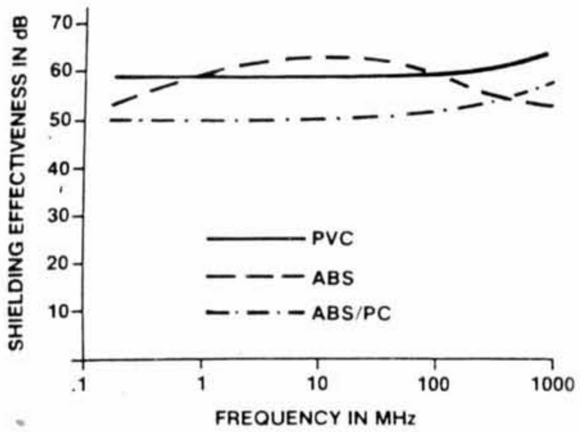


fig. 11. Shielding effectiveness in different types of plastic treated with solidified conductive flakes.

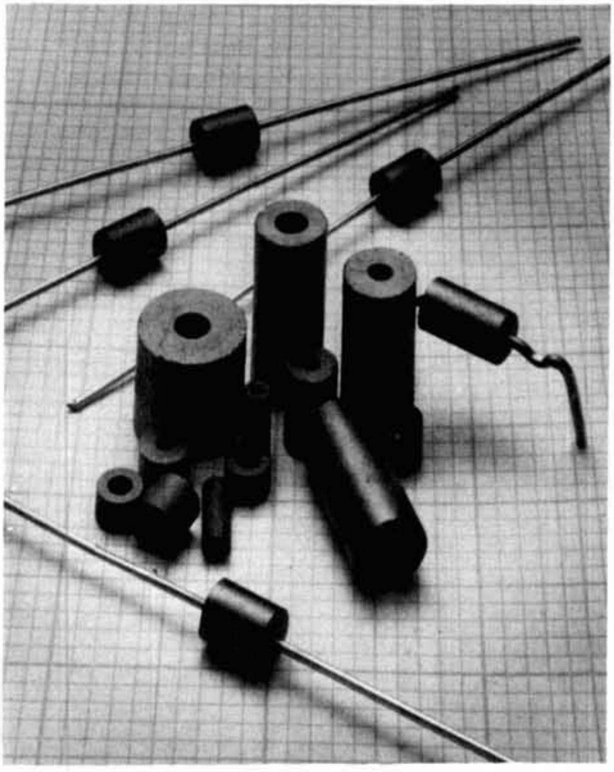


fig. 12. Ferrite beads for EMI suppression.

Although this method of testing is relatively new, it is gaining rapid acceptance. Sometimes called the Stutz method after its inventor, David E. Stutz of the Battelle Institute, this method is used to measure planar waves, whereas the shielded box method is used to measure the near field.

Conducted interference. As stated previously, conducted interference is best attacked at the source or through the cables or wires running to and from the box. These problems are usually of much lower frequency than EMI/RFI emissions and are the result of emissions from motors, transformers, and other magnetic field producers. Most hams know about ferrite beads (**fig. 12**), small ferro-magnetic metal or graphite tubular-shaped devices that slide over wires and suppress conducted emissions. Ferrite beads, however, become saturated at a certain current level; their attenuation does not increase with frequency; they tend to become a resonant frequency element, and there are often gaps because of poor fittings. Thanks to plastics, there are better ways to suppress conducted emissions. Zippertubing™*, for example, uses metallic mesh, aluminum foil laminated to vinyl-impregnated nylon, and high nickel-steel foil in standard jackets to form a protective shield fit over entire cable bundles (**fig. 13**), whether they are the traditional round bunched cables or the flat "ribbon" cables used by printers and modern computer equipment today. A new product now under development by Zippertubing, Inc., uses a plastic polyurethane material, PFR-20B, said to be even more rugged than these other jackets.

Berquist** is another innovative company that makes thermally conductive insulating pads that go between resistors and the PC board. This company, however, has gone one step further by laminating copper right onto the pad, (**fig. 14**). This now provides not only thermal conductivity but also EMI/RFI and conducted interference protection as well. While the metal does cause a capacitance between the transistor and its heatsink, the capacitance is limited to approximately 100 pF for a TO-3 power transistor.

To the ham on a limited budget, the best way to

fig. 13. Zippertubing conductive cable covers for suppression of conducted interference.

*Zippertubing, Inc., Los Angeles, California
**Berquist, Inc., Minneapolis, Minnesota

achieve magnetic shielding might be to use foil tape, which is comparatively inexpensive and comes in thicknesses of less than 0.002 inch to over 0.01 inch thick with permeabilities ranging from as low as 3,000 to over 350,000.

(If you are really fascinated by this subject, you may want to spend $99.50 and buy a kit from the Magnetic Shielding Division of Perfection Mica* (**fig. 15**). This contains sheets and foil forms, a magnetic pick-up probe, design information, and a variety of different types of shielding.)

"SIL-PAD SHIELDS" BERGQUIST

fig. 14. Thermally conductive heatsink pads with built-in conducted interference suppression.

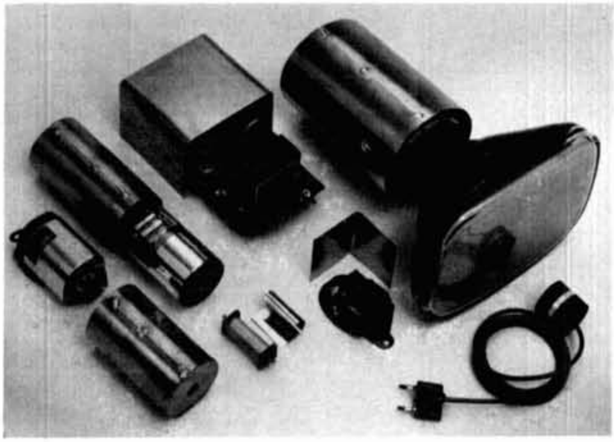


fig. 15. Kit for magnetic field shielding.

There is as yet no perfect coating, adhesive, or potting compound; EMI shielding with plastics is a science in itself. But with technology evolving rapidly in this area — and with many effective EMI-shielding materials becoming increasingly available — you need no longer invariably avoid using plastic cases in building equipment.

ham radio

*Perfection Mica, Inc., Bensenville, Illinois

HAM MART

Ham Radio's guide to help you find your loca

California

C & A ROBERTS, INC.
18511 HAWTHORN BLVD.
TORRANCE, CA 90504
213-370-7451
24 Hour: 213-834-5868
Not The Biggest, But The Best — Since 1962.

FONTANA ELECTRONICS
8628 SIERRA AVENUE
FONTANA, CA 92335
714-822-7710
714-822-7725
The Largest Electronics Dealer in San Bernardino County.

JUN'S ELECTRONICS
3919 SEPULVEDA BLVD.
CULVER CITY, CA 90230
213-390-8003
619-463-1886 San Diego
800-882-1343 Trades
Habla Espanol

Connecticut

HATRY ELECTRONICS
500 LEDYARD ST. (SOUTH)
HARTFORD, CT 06114
203-527-1881
Call today. Friendly one-stop shopping at prices you can afford.

Delaware

DELAWARE AMATEUR SUPPLY
71 MEADOW ROAD
NEW CASTLE, DE 19720
302-328-7728
800-441-7008
Icom, Ten-Tec, Microlog, Yaesu, Azden, Santec, KDK, and more.
One mile off I-95, no sales tax.

Florida

AMATEUR ELECTRONIC SUPPLY
1898 DREW STREET
CLEARWATER, FL 33575
813-461-4267
Clearwater Branch
West Coast's only full service Amateur Radio Store.
Hours M-F 9-5:30, Sat. 9-3

AMATEUR ELECTRONIC SUPPLY
621 COMMONWEALTH AVE.
ORLANDO, FL 32803
305-894-3238
Fla. Wats: 1 (800) 432-9424
Outside Fla: 1 (800) 327-1917
Hours M-F 9-5:30, Sat. 9-3

AMATEUR RADIO CENTER, INC.
2805 N. E. 2ND AVENUE
MIAMI, FL 33137
305-573-8383
The place for great dependable names in Ham Radio.

Hawaii

HONOLULU ELECTRONICS
819 KEEAUMOKU STREET
HONOLULU, HI 96814
(808) 949-5564
Serving Hawaii & Pacific area for 51 years. Complete lines of Amateur equipment, accessories and parts.

Illinois

ERICKSON COMMUNICATIONS, INC.
5456 N. MILWAUKEE AVE.
CHICAGO, IL 60630
312-631-5181
Hours: 9:30-5:30 Mon, Tu, Wed & Fri; 9:30-8:00 Thurs; 9:00-3:00 Sat.

Indiana

THE HAM SHACK
808 NORTH MAIN STREET
EVANSVILLE, IN 47710
812-422-0231
Discount prices on Ten-Tec, Cubic, Hy-Gain, MFJ, Azden, Kantronics, Santec and others.

Kansas

ASSOCIATED RADIO
8012 CONSER, P.O. BOX 4327
OVERLAND PARK, KS 66204
913-381-5900
America's No. 1 Real Amateur Radio Store. Trade — Sell — Buy.

Kentucky

L & S RADIO
307 McLEAN AVENUE
HOPKINSVILLE, KY 42240
502-885-8071
Ten-Tec, Azden, Ameritron Sales and Service.

Maryland

THE COMM CENTER, INC.
LAUREL PLAZA, RT. 198
LAUREL, MD 20707
800-638-4486
Kenwood, Drake, Icom, Ten-Tec, Tempo, Microlog, AEA, Ameritron.

Massachusetts

TEL-COM, INC.
675 GREAT ROAD, RTE. 119
LITTLETON, MA 01460
617-486-3040
617-486-3400 (this is new)
The Ham Store of New England You Can Rely On.

Michigan

ENCON PHOTOVOLTAICS
Complete Photovoltaic Systems
27600 Schoolcraft Rd.
Livonia, Michigan 48150
313-523-1850
Amateur Radio, Repeaters, Satellite, Computer applications.
Call Paul WD8AHO

Nevada

AMATEUR ELECTRONIC SUPPLY
1072 N. RANCHO DRIVE
LAS VEGAS, NV 89106
702-647-3114
Dale Porray "Squeak," AD7K
Outside Nev: 1 (800) 634-6227
Hours M-F 9-5:30, Sat. 9-3

JUN'S ELECTRONICS
460 E. PLUMB LANE — 107
RENO, NV 89502
702-827-5732
Outside Nev: 1 (800) 648-3962
Icom — Yaesu Dealer

New Hampshire

POLCARI'S ELECTRONICS CENTER
61 LOWELL ROAD
HUDSON, NH 03051
603-883-5005
Southern New Hampshire's only Ham Store. Call today for quotes.

Dealers: *YOU SHOULD BE HERE TOO!*
Contact Ham Radio now for complete details.

mateur Radio Dealer

New Jersey

RADIOS UNLIMITED
P.O. BOX 347
1760 EASTON AVENUE
SOMERSET, NJ 08873
201-469-4599
800-526-0903
New Jersey's only factory authorized Yaesu and Icom distributor. New and used equipment. Full service shop.

ROUTE ELECTRONICS 17
777 ROUTE 17 SOUTH
PARAMUS, NJ 07625
201-444-8717
Drake, Cubic, DenTron, Hy-Gain, Cushcraft, Hustler, Larsen, MFJ, Butternut, Fluke & Beckman Instruments, etc.

New York

BARRY ELECTRONICS
512 BROADWAY
NEW YORK, NY 10012
212-925-7000
New York City's Largest Full Service Ham and Commercial Radio Store.

VHF COMMUNICATIONS
915 NORTH MAIN STREET
JAMESTOWN, NY 14701
716-664-6345
Call after 7 PM and save! Supplying all of your Amateur needs. Featuring ICOM "The World System." Western New York's finest Amateur dealer.

Ohio

AMATEUR ELECTRONIC SUPPLY
28940 EUCLID AVE.
WICKLIFFE, OH (CLEVELAND AREA) 44092
216-585-7388
Ohio Wats: 1 (800) 362-0290
Outside Ohio: 1 (800) 321-3594
Hours M-F 9-5:30, Sat. 9-3

UNIVERSAL AMATEUR RADIO, INC.
1280 AIDA DRIVE
REYNOLDSBURG (COLUMBUS), OH 43068
614-866-4267
Featuring Kenwood, Yaesu, Icom, and other fine gear. Factory authorized sales and service. Shortwave specialists. Near I-270 and airport.

Pennsylvania

HAMTRONICS, DIV. OF TREVOSE ELECTRONICS
4033 BROWNSVILLE ROAD
TREVOSE, PA 19047
215-357-1400
Same Location for 30 Years.

LaRUE ELECTRONICS
1112 GRANDVIEW STREET
SCRANTON, PENNSYLVANIA 18509
717-343-2124
Icom, Bird, Cushcraft, Beckman, Larsen, Hustler, Astron, Belden, Antenna Specialists, W2AU/W2VS, AEA, B&W, Amphenol, Saxton, J.W. Miller/Daiwa, Vibroplex.

THE VHF SHOP
BOX 349 RD 4
MOUNTAINTOP, PA 18707
717-868-6565
Lunar, Microwave Modules, ARCOS, Astron, KLM, Tama, Tonna-F9FT, UHF Units/Parabolic, Santec, Tokyo Hy-Power, Dentron, Mirage, Amphenol, Belden

Texas

MADISON ELECTRONICS SUPPLY
1508 McKINNEY
HOUSTON, TX 77010
713-658-0268
Christmas?? Now??

Virginia

ELECTRONIC EQUIPMENT BANK
516 MILL STREET, N.E.
VIENNA, VA 22180
703-938-3350
Metropolitan D.C.'s One Stop Amateur Store. Largest Warehousing of Surplus Electronics.

Wisconsin

AMATEUR ELECTRONIC SUPPLY
4828 W. FOND DU LAC AVE.
MILWAUKEE, WI 53216
414-442-4200
Wisc. Wats: 1 (800) 242-5195
Outside Wisc: 1 (800) 558-0411
M-F 9-5:30
Sat 9-3

book and product

REVIEWS

HW-5400 HF transceiver

Regardless of his or her age, every Radio Amateur has heard "the rig here is an HW . . ." Back in the early 1960's, the first of the HW single-banders appeared on the scene, and were an instant hit. That unit spawned a whole line of units which included the SB-101, the SB-301, and many more. There are many more still going strong; and now, there's the HW-5400 microprocessor-controlled HF transceiver.

The HW-5400 has all sorts of interesting features. For instance, when I switched from one band to another, and then back to the first band, it was still tuned to the original frequency. In case of power failure, all the memories are automatically reset to the band edges.

It has split frequency operation, fast/slow AGC, VOX, and antiVOX. It's *all* there. One thing I especially like is the optional keypad frequency entry. I do quite a bit of split frequency work, and this feature makes operating easy; I've also found it handy when going off frequency from a net.

When the kit arrived, the first thing that impressed me was the weight of the power transformer. (Of course, the power supply is rated at 20 amperes, so I shouldn't have been surprised.) As soon as I opened the main carton, I was faced with a notice telling me not to unpack any parts until I was told to in the assembly procedure. I'm glad I followed the instructions. . .the packaging is indeed dense.

preliminary assembly

The assembly of the kit should take about one hundred hours, more or less. It is NOT a kit for someone who has had no experience in building kits. The instructions and illustrations are up to Heathkit standards, but a good deal of care has to be taken during soldering on some of the more tightly packed boards.

I took slightly less than one hundred hours to do the actual assembly, but I did encounter a couple of problems that used up quite a few extra hours. (It should have taken less, but I was being stubborn and didn't want to ask for help.) One of the areas where I got stuck turned out to be caused by a bad FET. And after some discussions with Heath, it turned out that the company was having some difficulties with this particular part. Heath and Motorola, the manufacturer, were working on the problem. The replacement FETs — which were sent promptly — worked fine, so the problem I encountered appears to have been resolved.

The kit has fifteen circuit boards, some of which are simple, with few parts. Others are not. But all are well made, and the silk screening job is good. While there is really no problem in stuffing these boards, I do recommend that you take the advice of good carpenters: measure twice, cut once.

At the end of the assembly of each board there is a series of tests to be made. In one, I found two solder bridges that I hadn't seen in my visual checks — and I was using a lighted inspection magnifier.

I had a great feeling of accomplishment when all the boards were finally done. Then I came to the section innocently titled "Chassis." At that moment I didn't realize that I was about to become an expert in crimping and soldering tiny Molex spring connectors on a multitude of ends of wires. After doing some 50 connections, I checked the price of a crimping tool: over $80. I continued my manual assembly procedures. (Perhaps Heath will develop a design for making a low-cost crimper, because using these connectors really helps during troubleshooting.)

final assembly

As I started the final assembly, I looked at the pile of boards I had just finished, and then at the main chassis, and wondered what kind of magic I was going to have to perform to get all that material onto one tiny chassis. The installation of the pre-assembled main cable harness is a good example of the kind of magic you'll have to perform; I suggest you start this step when you're feeling well-rested and kindly towards the world.

After doing the first two or three steps in the final assembly, I was instructed to mount the audio circuit board and make the necessary connections. Then came the instruction to "connect up a power supply" so that a series of operating tests could be made. It was only then I realized I should have built the power supply first. (I think perhaps it would have been wiser of Heath to mention this at the very beginning.) However, fortunately for me, I had "subcontracted" that part of the job to a ham friend who is normally a very active person (he goes up and down 70-foot towers like I go up and down stairs). He'd just had an extensive operation on one knee, and was "climbing the walls" with inactivity. He built my power supply in about six or seven hours.

All went well with the final assembly until the test of the synthesizer board: I just couldn't get the right readings. After following the "in case of trouble" charts and trying a few tricks of my

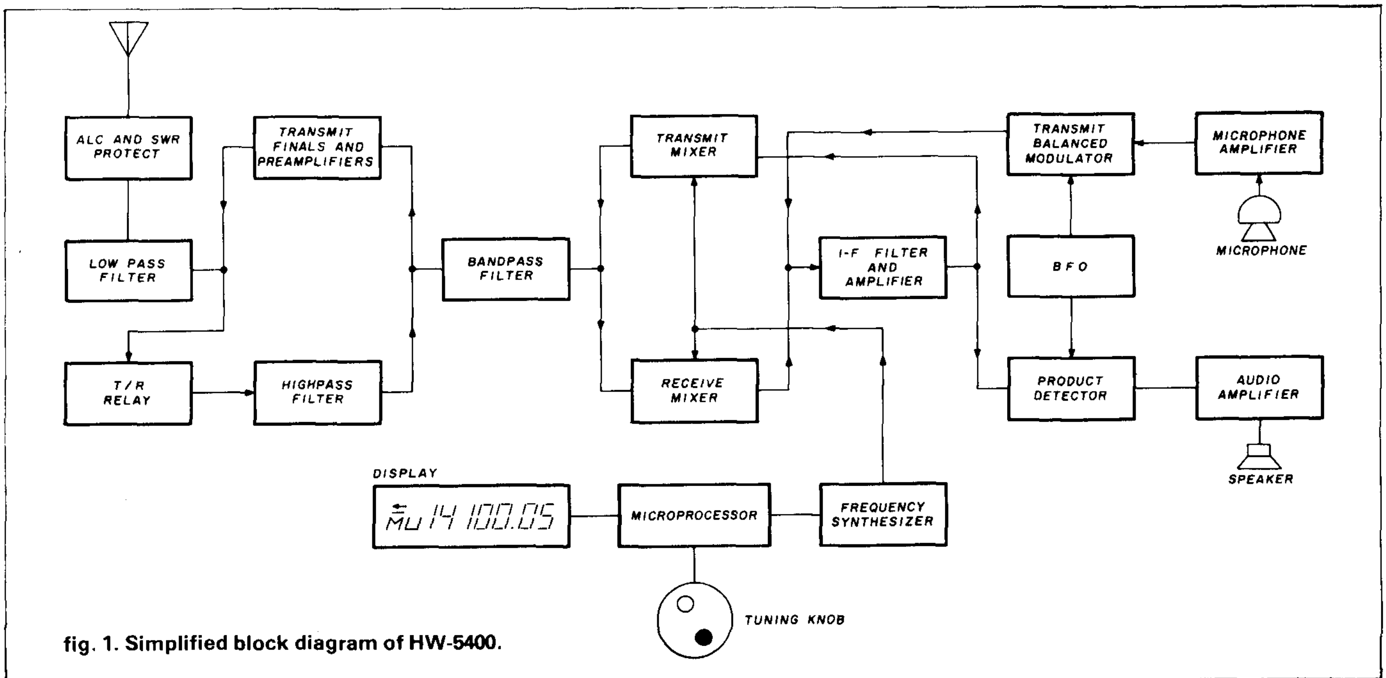


fig. 1. Simplified block diagram of HW-5400.

own, I called Heath. Very shortly, I was talking to Terry, a synthesizer expert, and listening to a quick run-through of that part of the circuit. He made a couple of suggestions and sure enough, his first one identified the trouble. It was a mica tuning capacitor that was marked 100 pF, but was really 1000 pF. No wonder the circuit wouldn't tune!

I ran into difficulty again on the IF board, but this time I didn't waste a moment; I got on the phone. It turned out that the trouble was the FET problem mentioned above. A package arrived in three days, and as it turned out, there were four FETs to be replaced.

When I had to remove the IF board, the synthesizer board, and the RF board, I was quite happy that Heath had made me put all those Molex connectors together. Disassembly was easy. It was at this point that the quality of the printed circuit boards became really obvious. I had absolutely no fear of unsoldering and resoldering the connections on the traces of the PCBs.

"smoke" test

There was one interesting thing about doing power-on tests after each step in the assembly. If you've ever put a kit together, then you know the thrill and fear of the "smoke test." With this rig you enjoy the same emotions over and over again. It doesn't lessen with experience.

Now there it was, all put together and ready for use. After three or four contacts on 75 and 20, I decided it was time to finish the job and install the unit in its cabinet. But first, I thought I should do a bit of peaking up, using my old but reliable General Radio Model 605A signal generator. There was no improvement.

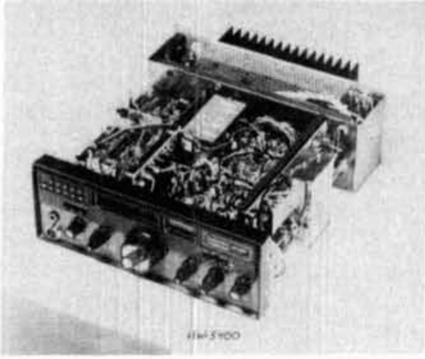
state-of-the-art circuitry

This is a complex, state-of-the-art transceiver. The simplified block diagram (**fig. 1**) shows the flow of signals. On both transmit and receive, the signals go through the lowpass filter (which is switched for each band). On receive, the signal goes through a highpass filter to get rid of broadcast band signals, and then travels through a bandpass filter which is also switched for each band. Notice that the BP filter is used on both transmit and receive. The signals go one way on transmit, and the opposite way on receive. This is done by some very clever diode switching. The final amplifier is permanently connected to the output. The transmit/receive relay is connected in the receive line, and is *opened* on transmit.

finger sensor

Down at the bottom of the block diagram are three blocks labeled DISPLAY, FREQUENCY SYNTHESIZED OSCILLATOR, and MICROPROCESSOR. They are NOT simple. The microprocessor is the device which makes everything happen in the HW-5400. It controls the display, the frequency synthesizer, and the finger sensor of the tuning knob. Yes, that's right . . . the *finger sensor*.

Now here's a bit of genius in design. The main



tuning knob has two finger-spinning holes. One of them has a metal insert. When your finger touches the metal insert, the two digits after the decimal on the display go out, and as you tune, the frequency increment is 1 kHz instead of 50 Hz. So when you want to make a big shift in frequency, use the metal insert spinner; for fine tuning, use the other one. On the unit that I built, I have the keypad accessory; for big jumps I use the keypad, and for 20 or 30 kHz, I use the spinner.

frequency control

The frequency synthesizer circuits control the VCOs, which combine to produce the required injection signal. The VCOs are controlled by a feedback loop referenced back to a crystal controlled oscillator. This loop has a bandpass filter, and the settling time for a VCO is inversely proportional to the bandwidth of the filter. The filter must be narrow enough to get rid of the reference frequency, and yet wide enough to allow quick response.

Heath solves the problem ingeniously. They set up the circuit so that the input to one of the divide-by-N chains is the difference between two VCOs. The step frequency of PLL 1 is 10.05 kHz; that of PLL 2, is 10 kHz. The difference between the two steps is only 50 Hz, yet the reference frequencies are at 10 kHz. This makes the filtering out of the reference frequency relatively easy. The output of VCO 1 is from 5.45-6.05 MHz (in 50 Hz steps). It is mixed with the BFO signal (8.83 MHz) to give 14.28-14.88 MHz. Then the signal is mixed with 10 or 20 MHz, and the output from VCO 3 or VCO 4, and the desired output frequency is produced. A lot of the switching is solid-state, so that the bandswitch is composed of only three wafers. One of those is used to control the solid-state switching circuitry.

The display on the HW-5400 is easy to read. At the left there is a series of symbols that indicate which mode the rig is in. There are several indicators — out of band, split frequency, transmit, and unlocked VCO. The VOX, anti-VOX, delay, and side tone controls are under a little flip-up panel to the right of the display.

When the Heath engineers laid out the printed circuit boards, they kept the transmit and receive parts pretty well separated, and generally speaking, the schematics follow the board layout in the same fashion. This makes it a little easier to locate the components on either the boards or the schematics.

operation

As I mentioned before, when I switched from one band to another, the HW-5400 remembered the frequency I last used on the original band. But it will also remember a second frequency. With eight bands (80, 40, 30, 20, 17, 15, 12, and 10), that makes a total of sixteen frequencies in memory, because the HW-5400 provides for split frequency operation on each band. Incidentally, when I operated split frequency, I found a slight delay in going from receive to transmit (but only on split frequency; simplex, the VCOs are already on frequency and there is no delay). This happened because the VCOs require a little time to settle.

I found it strange to be able to switch from one band to another without having to retune; in fact, I kept looking for the knobs. Fortunately, all of my antennas have fairly low SWR. At least they are low enough so that the HW-5400 will accept them without shutting down. Just to see what would happen, I put the rig on 75 meters and left the 20 meter beam antenna connected. The HW-5400 absolutely refused to put out any power. I didn't do any fancy tests to see at what SWR it would quit, but I figure that this is the mistake most likely to be made.

One disconcerting thing at first was "chirp" of the 50 Hz steps as I tuned in a CW or RTTY signal. But soon I no longer noticed the noise. For final tuning of signals, I started to use the RIT. It is smooth. Another feature I like is the IF shift. It seems to me that whenever I go off a net to talk to someone, the frequency I select invariably becomes the channel adjacent to the National Tuneup Frequency! With the IF shift, I can slide the IF sideways a little and get rid of the QRM. It's a nice feature.

While the high speed tuning feature is great, it did produce a surprise one evening. I spun the dial to a new frequency to meet someone for a QSO, and because Heath included a muting circuit to quiet the receiver while the VCO is settling, I ended up about 15 kHz past a local. He was transmitting when I tuned past him, but it took a few milliseconds before the speaker almost came off the desk from the buckshot. It took me a second or two to realize what had happened. I moved down another 15 or 20 kHz and learned something: the HW-5400 is almost as good as my tube rig for bearing up under close-by locals. I carried on the QSO about 30 kHz from the local, and although I knew he was there, it wasn't difficult or even uncomfortable to carry on the QSO.

Radio Amateurs are never satisfied. It doesn't much matter who designs what . . . we'd always like to see something different. For me, there are two things missing from the HW-5400: 160 meters and a way to connect up my SB-610 band scanner. After having used one for fifteen years or so, I feel almost lost without it connected.

One of the things I really like about this rig is the uncluttered front panel; you can tell what each control is for without searching through the instruction book. The knobs are far enough apart so that I don't feel crowded.

If you like to build, and have some experience at it, the HW-5400 is a good rig to tackle. If you want to dig inside to fix or tweak something, you'll be able to go ahead with confidence because you'll have been inside at least once before. You'll enjoy operating the HW-5400; it's a good rig.

For information on the HW-5400, contact Heath Company, Benton Harbor, Michigan 49022.

Fred Looker, VE3ZL

HW-5400: specifications

coverage:	80,40,30,20,17,15, 12,10 meters plus WWV at 10 MHz
readout:	7-digit display, vacuum fluorescent with special symbols
readout accuracy:	to nearest 50 Hz
frequency control:	synthesized
memory storage:	2 frequencies/band
stability:	less than 50 ppm drift from cold start
modes:	SSB normal and reverse CW — wide and narrow
receiver	
sensitivity:	less than 0.35 μV for 10 dB $\frac{S+N}{N}$
audio output:	2 watts in 4 ohms
AGC:	selectable (fast or slow)
intermod:	70 dB at 25 kHz
transmitter	
RF output:	100 watts except on 10 meters (80 W)
load impedance:	90% rated power at 2:1 SWR high SWR protection
transmit-receive:	SSB: PTT or VOX CW — full break-in (simplex only)
general	
dimensions:	11½ × 14 × 5 inches (29.2 × 35.6 × 12.7 cm)
weight:	24 pounds (10.9 kg)
power:	13.8 volts DC at 20 amperes (HWA-5400-1 power supply: 120/240 V, 60 Hz)

book review: radio frequency design

Wes Hayward, W7ZOI, an engineer from Tektronix, is well known to the Amateur and professional community. His numerous efforts to educate designers in both detailed schematics and system approach have led him to write *Introduction to Radio Frequency Design*, published by Prentice Hall in January, 1982.

Having seen many books on this subject, I was impressed with the way this one was composed and the way issues are addressed. The book consists of eight chapters covering low frequency transistor models, filter basics, coupled resonator filters, transmission lines, two-port networks, amplifiers and mixers, and oscillators and frequency synthesizers. A final chapter is titled "The Receiver: An RF System."

The material presented is complete; references are well chosen. The book reads easily and makes one feel sufficiently impressed to keep on reading. I was tempted to use my computer resources to verify some of the more complex numerical examples, and I was not surprised to find that the author's calculations were correct. I especially enjoyed a few specific items (his non-linear model of the transistor and his analysis of noise, for example) and recommend these sections — and the book as a whole — to all readers. *Introduction to Radio Frequency Design* is thoroughly enjoyable and well worth the $29.95 investment.

DJ2LR

Sherwood filters

Receiver selectivity and the ability to reject unwanted signals are subjects of tremendous interest to Radio Amateurs. Long known for their excellent aftermarket filters and extensive modification of the R4C receiver, Sherwood Engineering now has a line of front end antenna filters. My interest came as a result of a phone call from George Heidelman at Sherwood alerting me to a new filter they had designed recently for the 160 meter DX window, 1.825-1.830 MHz.

If you haven't been on 160 meters recently, you would be surprised by the amount of activity that will be found. On almost any given evening there are plenty of CW and SSB QSO's in progress; rapid growth and the elimination of power restrictions has resulted in some crowding on the band. For instance, SSB operators who sit just above 1.830 MHz with an LSB signal put a fair part of their signal down into the DX window.

During both phone and CW contests, when 160 can sound as bad as 20 meters, the DX window is often bracketed by strong signals. For the average transceiver or receiver, this can result in very difficult copy in the DX window area. Installation of the Sherwood filter will pass only these signals that fall between 1.825 and 1.830 MHz thus facilitating easier reception without front-end overload, intermodulation products, etc. Another suggested application is at large multi-op, multi-transmitter contest stations; a spotter can scan the DX window, minimizing interference, while the operator is working stations on another part of the band. When another multiplier is heard, the operator can QSY to the appropriate frequency and attempt to work the station.

The filters can also be used to reduce interference from high powered shortwave broadcast stations and in high ham density, urban environments. Currently Sherwood Engineering has available filters that cover 25 kHz segments for the 40 and 20 meter CW bands, 12.5 kHz segments of 80/75 meters, and any 5 kHz segment on 160 meters. Other frequencies are available on request.

These low-loss front-end antenna filters are based upon a high performance, 6 pole, crystal 50 ohm design. They have a shape factor of 2.25:1, 6/60 dB and are designed to be used with any receiver and can be adapted to most transceivers.

the acid test

After receiving the filter from Sherwood, I reconfigured my receiver input so that I could switch in and out the filter to do A-B comparisons. Because I live in a low-density area, having other stations nearby is not a problem. However, as more and more new hams have joined the fun on 160 meters, the band has become significantly more crowded. During several 1983 contests, I found that while listening with the filter in, I was able to effectively reduce interference coming from other stations outside the DX window. At the filter's edges, nearby signals were not completely eliminated due to operating at the 3 dB points. My overall impression of these front-end filters is that they would be highly desirable at a multi-op, multi-transmitter operation and in any high ham density area. For 160 meters, they provide an extra measure of selectivity to help ferrett out those weak and hard-to-copy DX signals. They can also be used ahead of a Beverage antenna preamplifier.

Filters for several frequency segments are available for each band. They include the FE-14000/6, FE-14200/6, FE-7000/6, FE-3500/6, and FE-1825/6, as well as others that may be specially ordered. Most are priced at $80; 160 meter filters are priced at $145. Add $3 for domestic shipping, $6 for shipping overseas.

For more information on Sherwood's front-end filter or any of the rest of their product line, contact Sherwood Engineering, 1268 S. Ogden Street, Denver, Colorado 80210.

Circle #302 on Reader Service Card.

— **N1ACH**

NEW products

remote control antenna tuners

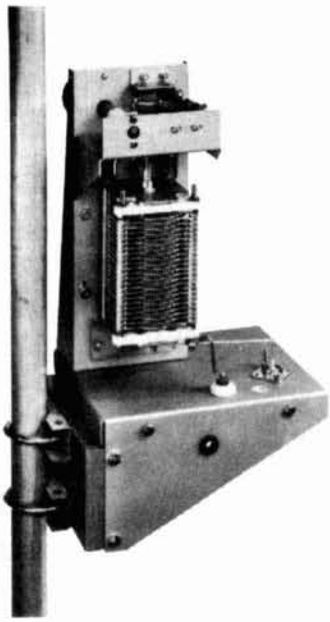
Here's a brand new product of interest to hams who've been disappointed with their antenna's performance. The VT-3/VT-4 is a remotely tuned series-fed capacitor that is connected directly to the antenna. Adjusting the VT-3/VT-4 will tune the antenna to a minimum value of SWR. For example, mobile antennas that would before only tune 20 kHz without readjustment, will now be able to tune the whole band by a flick of the switch. Other suggested uses are with a trapped vertical, half wave doublet, long wire, or sloper.

The VT-3/VT-4 is housed in an aluminum universal base mount with an anodized aluminum cover for weather protection. With the addition of the LC-4 inductor kit, it can be converted to a voltage-fed matching device. This is a single band system that can cover 1.8-30 MHz and will provide full size band coverage with appropriate coil tap adjustment.

The VT-3 is designed for mobile installation and operates directly from the vehicle's 12-volt power supply. The VT-4 is a 117 VAC - 12 VDC supply and switch. The VT-3/VT-4 has a switch to activate the capacitor and limit lights show when either maximum or minimum capacitance values are reached. Both units require eight conductor control cables. Current consumption is low so cable runs can be long.

NEW products

Price for the VT-3/VT-4 is $159.95. Eight conductor cable is available for 24 cents per foot and the LC-4 inductor kit is priced at $39.00. All Vector Radio products are sold with a money-back guarantee.



For more information on the Vector Radio VT-3/VT-4 remote antenna tuner, contact Vector Radio Co., P.O. Box 1166, Cardiff, California 92007.

Circle #303 on Reader Service Card.

radio modem

Macrotronics, Inc. has introduced the RM1000 radio modem, a hardware and software system that converts a personal computer into a state-of-the-art communications terminal supporting Morse, Baudot and ASCII codes. The radio modem is intended for use by Amateur Radio operators and SWL's for copying news and wire sevices. It features commercial quality demodulators, dual bargraph tuning, and extensive software capabilities.

The RM1000 uses multistage active filter demodulators with dual LED bargraph tuning indicators for reception of both Morse code and radioteletype (RTTY) signals. It offers three RTTY shifts which may be selected from the computer keyboard, and a crystal-controlled AFSK tone generator provides stable RTTY keying. Relays are used for Morse code and push-to-talk transmitter keying. A hardware clock continuously displays time and may be inserted into text in a completely user-programmable format.

Many features are included in the software to accommodate a wide variety of operating situations including net operations, MARS, RTTY, art ("PIX"), contesting and SWLing. A 70-page user manual is included.

The RM1000 radio modem system is currently available for ATARI™, APPLE™, IBM™ and Radio Shack TRS80™ microcomputers. For complete information, contact Macrotronics, Inc., 1125 N. Golden State Blvd., Turlock, California 95380.

Circle #304 on Reader Service Card.

new solid-state tube for Drake R-4

Sartori Associates has just announced the availability of a new solid-state tube, the SBA6. Designed to replace the 6BA6 in Drake R-4(A-B-C) receivers, the SBA6 will also replace the RF and IF 6BZ6 vacuum tubes in the R-4A/B and early model R-4C, as well as the 6BA6 and 12BA6 vacuum tubes used in the IF amplifiers of the R-4 series. (For the third mixer in the early model R-4C, we recommend replacing the 6BA6 with a 6HS6/SHS6 — (Drake made this improvement in the mid-model R-4C). The new SBA6 will also serve as a plug-in replacement for your T-4X 12BA6 ALC'd IF amplifier.

Sartori solid-state tubes provide no-warm-up, high performance, trouble-free operation with R-4(A-B-C) receivers. Sartori also manufactures SEJ7, SHS6, and SBE6 mixers for the R-4 series and the SEJ7, SHS6, SAU6, SAX7-1, SAX7-2, SEV7/SFQ7/SAQ8 for the T-4X series. All are priced at $23.00 postpaid.

For more information about the SBA6, contact Sartori Engineering, P.O. Box 2083, Richardson, Texas 75080.

Circle #305 on Reader Service Card.

IC-04A and IC-04AT

The IC-04A and IC-04AT, two new 440 MHz HTs from ICOM, feature frequency entry, control functions and 32 PL tones controlled by the 16-button pad on the face of the radio. Also in-

cluded are priority, scanning (both of memories and programmable band scan), and DTMF (04AT only). For scanning, 5 kHz increments are front-panel selectable. Ten memories with internal lithium battery backup give the ultimate in flexibility for channelizing operation for easy access to most-used channels. A custom LCD readout with S-meter is unique to the ham industry.

The IC-04A and IC-04AT have the same styling, control features and functions of the IC-02A(T), and utilize the existing accessory line available for the IC-2A and IC-2AT, plus new accessories such as long-life and high-power battery packs.

For details, contact ICOM, 2112 116th Avenue, N.E., Bellvue, Washington 98004.

Circle #308 on Reader Service Card.

full-function DTMF decoder

A full-function, dual-tone multifrequency decoder module, model 2009, is a state-of-the-art CMOS design which decodes all 16 DTMF codes. Available from Proham Electronics, model 2009 has several advanced features such as a crystal-controlled timebase for long-term accuracy, on-board voltage regulation, counter detection with period averaging to minimize falsing, and latched 4-bit digital outputs with a choice of binary or row/column format.

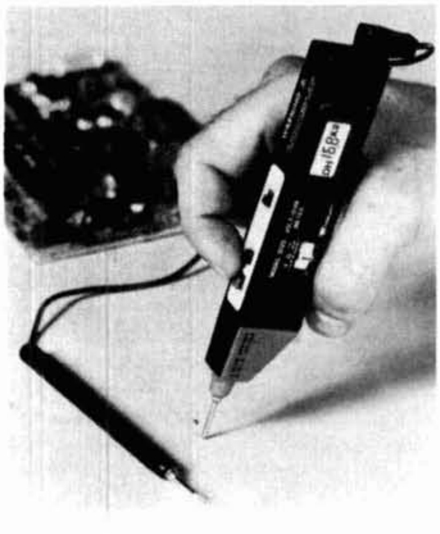
Two LSI CMOS chips provide high performance operation and minimize the parts count. All bandpass and band reject filtering is achieved by using one switched-capacitive filter integrated circuit. The time base oscillator and dividers are also within this chip. Likewise, the actual decoding is performed by the second CMOS device. This simplifies operation, since there is only one adjustment required, and it sets the operating level. There are no frequency adjustments because all timing is referenced to the crystal controlled time base. Ancillary benefits resulting from the application of these LSI CMOS devices is compact size, the printed circuit board is only 3.6 × 2.0 inches, and low power requirement, typically 40 mA at 12.5 VDC. The kit is easy to build using the comprehensive instruction manual supplied, and easy to use. When driven with an audio signal beween 50 mV and 1.0 V, the model 2009 produces a 4-bit digital output code corresponding to the DTMF digit detected and valid code pulse. This output can be used to drive a parallel port of a microcomputer or additional digital logic circuitry as required. The price of a bare board with manual is $9.95; board, manual, filter and decoder chip, $44.95; complete kit, $99.95; and manual only, $5.00. All prices include postage in U.S.A. (Ohio residents add 5% sales tax.)

For further information, contact Proham Electronics, Incorporated, 34620 Lakeland Blvd., Eastlake, Ohio 44094.

Circle #306 on Reader Service Card.

shirt-pocket volt-ohmmeter

The new Model 3525 DIGI-PROBE™ volt-ohmmeter, just introduced by Triplett, is said to be one of the smallest trouble-shooting, battery-operated, digital instruments presently manufactured. Its shirt-pocket size, internal overload protection, accuracy and auto-ranging features make it appropriate for a myriad of



lab, circuit design or in-field measurements on industrial, commercial, or consumer electronic/electrical equipment.

Only 6-3/8" long × 1-1/8" wide × 3/4" deep (162 × 28 × 20 mm), the DIGI-PROBE™ utilizes a large 5mm easy-reading 3.5 digit LCD display with a convenient "Data Hold" feature to facilitate measurements in low ambient light or in confined areas. It also enables the user to "hold" the reading for later review. An instant-tone continuity test permits rapid testing of diodes, shorts and circuit continuity. Volts, ohms, and continuity are easily selected with a simple function switch. AC and DC volts are selected by push-button with AC shown on the LCD display.

Auto-ranging on volts and ohms functions eliminates the need for range selection, providing true "Touch and Test" capability. The Model 3525 has thirteen ranges. Range selection in all functions is fully atuomatic. The ranges are: 0-500 VDC in four ranges; 0-500 VAC in four ranges; 0-2.0 Megohms (2.9 Megohms in overrange) in four ranges. Auto-ranging response time is 5 seconds maximum and accuracy is ±0.75 percent of RDG + two digits on most ranges. Blinking-digit overrange indication and low battery visual indication are provided. Internal overload protection is to 750 VAC/DC in voltage ranges and 250 VAC/DC in ohms and continuity ranges.

The DIGI-PROBE™ case is molded of high impact black thermoplastic with textured surface. The unit weighs only 2-1/2 ounces (0.07 kg).

Priced at $65.00, the DIGI-PROBE™ is furnished with two 1-1/2 volt button-type batteries, shirt-pocket carrying case, attached 28-inch test lead, comprehensive instruction manual and one-year warranty.

For information or a free demonstration of the DIGI-PROBE™ contact Triplett Corporation, One Triplett Drive, Bluffton, Ohio 45817.

Circle #309 on Reader Service Card.

noise figure measurements application note

HP's new application note AN/57-1, "Principles of RF and Microwave Noise Figure Measurement," is now available for all those working on device, component, sub-system and system noise figure. It replaces the long-popular AN/57, "Noise Figure Primer."

The 40-page note serves as a comprehensive tutorial on noise figure, with detailed material on thermal and shot noise, concepts of noise figure, effective noise temperature, Y-factor, etc.

Plenty of useful information is provided on subtle measurement considerations including single sideband vs. double sideband, effects of local-oscillator noise, second-stage effects and corrections, hot/cold techniques, frequency conversation and image considerations.

An extensive glossary includes common symbols and detailed technical explanations of most terms. Also included is a bibliography of 34 other noise-figure-related references.

For a free copy of AN/57-1, contact Hewlett-Packard Company, 1820 Embarcadero Road, Palo Alto, California 94303.

Circle #307 on Reader Service Card.

flea market

RATES Noncommercial ads 10¢ per word; commercial ads 60¢ per word **both payable in advance**. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing) on a space available basis only. Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (**not** all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N. H. 03048.

QSLs & RUBBER STAMPS — Top Quality! Card Samples and Stamp info — 50¢ — Ebbert Graphics 5R, Box 70, Westerville, Ohio 43081.

TRAVEL-PAK QSL KIT — Converts post cards, photos to QSLs. Stamp brings circular. Samco, Box 203-c, Wynantskill, New York 12198.

QSL the Best! Full color $20 for 200. As low as $7. Free catalog. Rusprint, Box 7575, Kansas City, MO 64116. Credit card order line 1-800-531-7373.

SPRING CLEANING. All must go. Test equipment: H.P. scopes, meters, G.R. bridges, Tektronix equip., lab standards, spectrum analyzers, many other items, antiques; parts: insulators, gears, fans, variacs, much more. Also electronics databooks, finest current material, radio magazines, really cheap, test equipment manuals. Send long SASE for giant shack cleanout list. Joseph Cohen, 200 Woodside, Winthrop, MA 02152.

COUNSELORS: Connecticut brother-sister camp. Completely equipped with ham radio station. Program includes electronics, kit building, code and communications. June 25 - August 22. Send resume: Lloyd Albin (N2DMQ) Ken-Mont and Ken-Wood Camps, 2 Spencer Place, Scarsdale, NY 10583.

FOR SALE: Heathkit SB 104A with complete mods. Spare PA board. Power supply, ext. VFO. Best offer. S. Pavone, 201-335-5732.

NEED TO CONTACT James Navarchi concerning Yaesu gear. C. T. Huth, 146 Schonhardt St., Tiffin, OH 44883.

FASTRAK · 2005 Active filter features 8-pole response and dc switching; make a CW filter with 80 hertz bandwidth; 3.6 × 3.0 inch pcb and manual $9.95. Proham Electronics, Inc., 34620 Lakeland Blvd., Eastlake, OH 44094.

PROFESSIONAL QUALITY circuit boards at ham prices. Catalog $1.50. Dynaclad Industries, Box 296, Meadowlands, PA 15347.

KENWOOD TS-520, CW filter, extra VFO, service manual, ac/mobile power supply $419. Heath HW-12, power supply $65. EE-8 field telephones $22 each. I pay shipping. W8QX. (313) 644-5042.

SUPER CQWW AND ARRL CONTEST PROGRAMS. *TRS-80* Model I, III, (IV in III mode). Completely machine language. Automatic identification of country and zone (CQ) from call letters. Dupe speed 12000 + contacts per second. Screen displays zones still needed (CQ), total points, zones, countries, etc. Automatic CW generator with 2 buffers. Log print program prepares logs and dupe sheets. Log preparation program for hand logs. Similar features to above. QSL label program for both. CQ WPX now being written. FREE fact sheet and sample printouts. K4SB, 3496 Velma Drive, Powder Springs, GA 30073.

120' GUYED TOWER. Extremely strong $700. 20' sections $150. Tim Colbert, 13609 Colony, Burton, Ohio 44021.

VLF-LF preamps, coupler, Loran-C boards. SASE. Burhans Electronics, 161 Grosvenor St., Athens, Ohio 45701.

FASTRAK · *2007 interval timer uses digital logic to provide accurate timing without falsing; adjustable length; ideal for 10 minute id use;* 3.6 × 1.5 inch pcb and manual $9.95. Proham Electronics, Inc., 34620 Lakeland Blvd., Eastlake, OH 44094.

ELECTRON TUBES: Receiving, transmitting, microwave . . . all types available. Large stock. Next day delivery most cases. Daily Electronics, 14126 Willow Lane, Westminster, CA 92683. (714) 894-1368.

RUBBER STAMPS: 3 lines $4.50 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

RECLAIM SILVER from electronics scrap. Write RALTEC, 25884F Highland, Cleveland, OH 44143.

CHASSIS and cabinet kits. SASE K3IWK.

WANTED: Manual for Lavoie oscilloscope model LA-265A. Original or photocopy. State cost. WE4O, 4257 Via Alta Drive, Mobile, Alabama 36609.

SALE: Vanguard Labs signal generator 100 to 180 MHz. Johnson CB test set. *Checks power, modulation and receiver.* Jeff V. Nielson, 610 South 200E, Monroe, Utah 84754. (801) 527-4242.

CABLE CONVERTERS, decoders. Catalog $1 refundable. APS, POB 263 HR, Newport, RI 02840.

RECONDITIONED **TEST EQUIPMENT** $1.00 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

RTTY-EXCLUSIVELY for the Amateur Teleprinter. One year $7.00. Beginners RTTY Handbook $8.00 includes journal index. P.O. Box RY, Cardiff, CA 92007.

FILTERS for Drake R-4C receiver FL-250, FL-500, FL-1500, new, each $55.00; HP-608FR late model signal generator, 10 MHz thru 455 MHz, 19" panel with blue/gray cabinet, $375.00; USM-140 oscilloscope, DC-25 MHz dual trace, triggered sweep $295.00; URM-26 signal generator 4 MHz thru 400 MHz, $185.00; Jerrold 900A sweep generator, 500 kHz thru 1200 MHz, $325.00; Tektronix L-30 spectrum analyzer plug-in 925 MHz thru 10.5 GHz, $345.00. All excellent lab tested, add shipping, phone 704-524-7519. Slep Electronics Company, Highway 441, Otto, NC 28763.

IMRA International Mission Radio Assn. helps missioners — equipment loaned; weekday net, 14.280 MHz, 2-3 PM Eastern. Br. Frey, 1 Pryer Manor Rd., Larchmont, NY 10538.

"HAMS FOR CHRIST." Reach other Hams with a gospel tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

QUICK-FIND Callsign log. Quickly know if and when you worked that call, and if you want to work it again! $2.00, full price, Quick-Find, 2725-H Sandicrest, Cantonment, Florida 32533.

ENGINEERING SOFTWARE: Free brochure. SPP — Signal Processing Program. General purpose program analyzes linear and non-linear systems and circuits and their effects on user specified waveforms. Transient analysis, 512 point FFT & Inverse FFT. Laplace transfer function analysis and manipulation. Non-linear time domain manipulation. Works with ACNAP to provide transient analysis for linear circuits, PLOTPRO to plot results. Too much to tell, write for brochure. $59.95 ACNAP — Fast Electronic Circuit Analysis Program analyzes active & passive circuits up to 60 components and 21 nodes. Calculates Worst Case, Monte-Carlo, Sensitivities, Noise Equivalent Bandwidth, linear or log steps, disk file I/O, works with PLOTPRO and SPP. $49.95. PLOTPRO — Microsoft Basic program makes scientific graphs using any printer. Linear, semi-logarithmic, logarithmic plots, one or two Y axis. Plots multiple functions on same graph, forced scaling or autoscaled, grid lines and labeling. Vertical and Horizontal formats, $49.95. All programs available for 5.25/8" CP/M, IBM PC, VICTOR 9000, and TRS-80 Models I, III, IV. Include $3.00 each shipping & handling, California add 6%. BV Engineering, P.O. Box 3351, Riverside, CA 92519, (714) 781-0252.

TENNATEST — Antenna noise bridge — out-performs others, accurate, costs less, satisfaction guaranteed. Send stamp for details, W8URR, 1025 Wildwood Road, Quincy, MI 49082.

WANTED: Cash paid for used Speed Radar equipment. Write or call: Brian R. Esterman, P.O. Box 8141, Northfield, Illinois 60093. (312) 251-8901.

WANTED: Old RCA, Western Electric tubes. (713) 728-4343. Maury Corb, 11122 Atwell, Houston, Texas 77096.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

SELL: Kenwood Twins. E. Alline, NE5S, 773 Rosa, Metairie, LA 70005.

VERY in-ter-est-ing! Next 4 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60189.

IBM-PC ASCII/BAUDOT/CW. SASE for details. E. Alline, NE5S, 773 Rosa, Metairie, LA 70005.

ANNIE's EASY. Analyze dipoles, slopers, verticals, inverted-vees and arrays; any orientation, position, phasing, weight or combination with Annie Antenna Analysis Software. Include REAL GROUND (conductivity, dielectric constant). Superb hi-res plotting. Annie's incredibly friendly and with 100% machine language, she's FAST! For Apple II + (48K or 64K) or IIe, DOS3.3, $49.95 + $2.00 postage, NY add sales tax. Include full name and call. S.A.S.E. for info. Commercial, library, etc., call for quote (315) 622-3641. Sonnet Software, Dept. HR, 4397 Luna Course, Liverpool, NY 10388.

KEYBOARD and instruments cases. Send for free information. Bel-Tek, PO Box 125H, Beloit, WI 53511.

WANTED: ARRL VHF Manual, early edition. State condition and year of publication. Stanley Jaffin, WB3BGU, 800 Stonington Road, Silver Spring, Maryland 20902. Telephone 301 593-5959, evenings.

Coming Events

ACTIVITIES

"Places to go..."

OHIO: The Cuyahoga Falls ARC's 30th annual Electronic Equipment Auction and Hamfest, Sunday, February 26, North High School, Akron. 8 AM to 4 PM. Tickets $2.50 advance, $3.00 at door. Sellers may bring own tables or some available for $2.00, advance table reservations advised. Talk in on 87/27. For information: CFARC, P.O. Box 6, Cuyahoga Falls, OH 44222 or call K8JSL (216) 923-3830.

INDIANA: The LaPorte Amateur Radio Club's Winter Hamfest, Sunday, February 26, Civic Auditorium in LaPorte. Starts 7 AM Chicago time. Admission $2.50 per person. 8 ft. long tables available for $2.00 each by reservation. Good food, coffee, etc. Talk in on 52 simplex. SASE for tables, tickets, or information to LPARC, P.O. Box 30, LaPorte, IN 46350.

MICHIGAN: The 14th annual Livonia Amateur Radio Club's Swap 'n Shop, Sunday, March 4, 8 AM to 4 PM, Churchill High School in Livonia. Plenty of tables, refreshments and free parking. Talk in on 144.75/5.35 and 52 simplex. For further information send large SASE to Neil Coffin, WA8GWL, Livonia ARC, P.O. Box 2111, Livonia, MI 48151.

OHIO: Cincinnati ARRL '84 State Convention and Flea Market, February 25 and 26. Registration $5. Flea market $4 per space both days. Forums, meetings, vendors, Wouff Hong, banquet. Hospitality suite Friday and Saturday nights. Write: Cincinnati ARRL '84, POB11300, Cincinnati, OH 45211 or call (513) 825-8234.

KENTUCKY: Glasgow Swapfest, Saturday, February 25, 8 AM CST til . . . Glasgow Flea Market Building 2 miles south of Glasgow off highway 31E. Large flea market, free coffee, free parking. Admission $2 per person, no extra charge for exhibitors. One free table per exhibitor, extra tables available for $3.00 each. Talk in on 146.34/94 or 147.63/03. For information: WA4JZO, 121 Adairland Ct., Glasgow, KY 42141.

NEW JERSEY: Springfest '84 sponsored by the Shore Points ARC, Saturday, March 10 from 9 AM to 4 PM, Atlantic County 4-H Center, Egg Harbor City, approx. 15 miles west of Atlantic City. Large heated, indoor selling space. Covered tailgating (weather permitting). Sellers $5 per space with own table. Buyers $2.50 advance, $3.00 day of hamfest. For information, SPARC, P.O. Box 142, Absecon, NJ 08201.

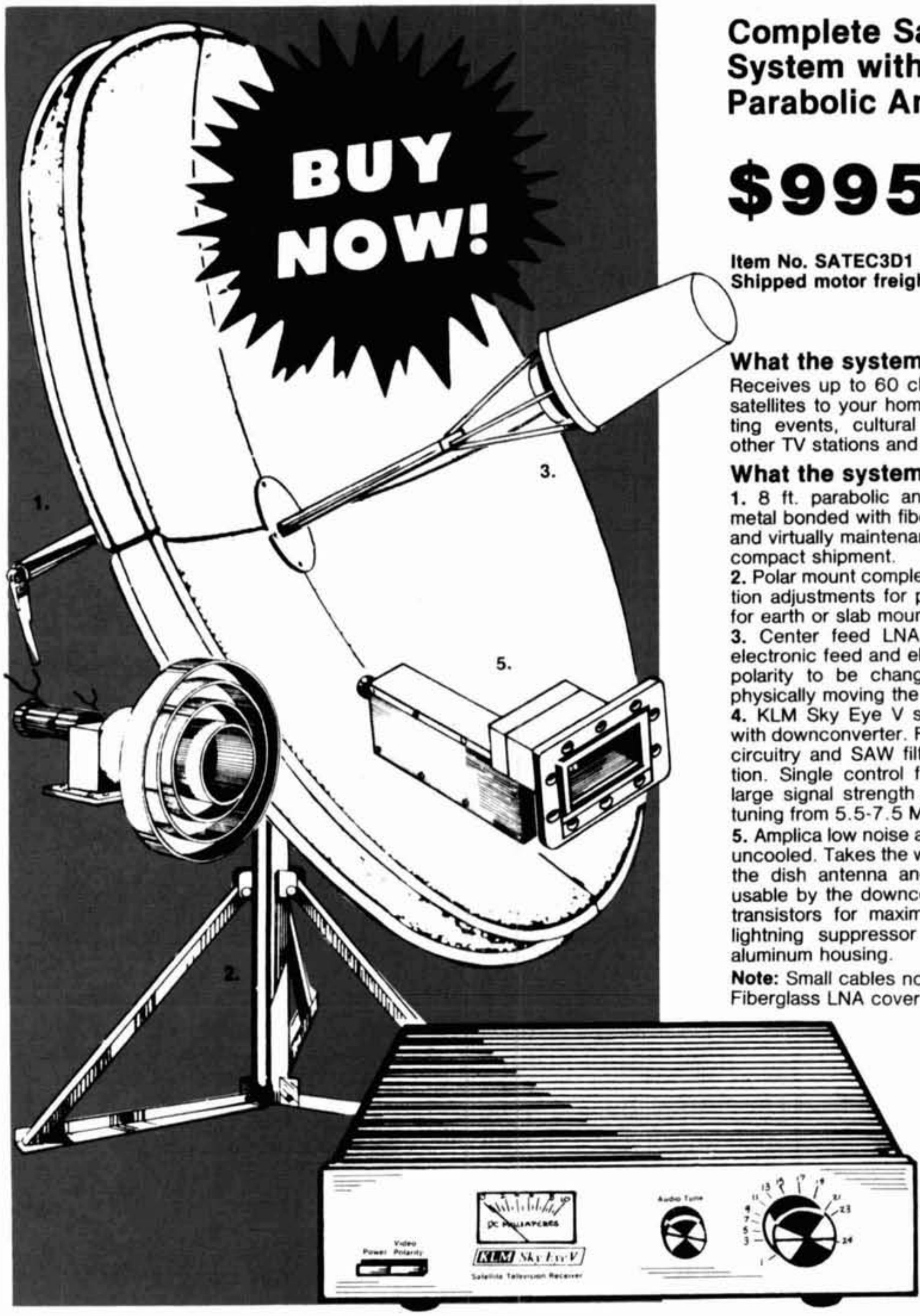
PENNSYLVANIA: The 1984 Lancaster Hamfest, Sunday, February 19, Guernsey Sales Pavillion, U.S. Rts. 30 and 896, Lancaster. 0800 to 1600, dealer setup 0600. Commercial tables (main hall) $15.00. Non-commercial (rear annex) $6.00. General admission $3.00. Tailgating free with general admission (weather permitting). Talk in on 146.61 and 147.015. Send reservations to Hamfest Committee, P.O. Box 6082, Lancaster, PA 17603. Please make checks payable to SERCOM, Inc.

MICHIGAN: The Cherryland Amateur Radio Club's 11th annual Swap N Shop, February 11, Immaculate Conception Elementary School gym, 218 Vine Street, Traverse City, 8 AM to 2:30 PM. Tables $3.00 each with setup at 6:30 AM. Admission $2.50. Talk in on 146.25/.85. For details SASE to Jerry Cermak, K8YVU, 3905 Slusher Rd., Traverse City, MI 49684.

OPERATING EVENTS
"Things to do..."

FEBRUARY 1 TO 12: NORAC (North Okanagan Radio Amateur Club) will be operating a special event station during Western Canada's largest Winter Carnival. NORAC will operate VE7NOR from 21.00 Z to 24.30 Z during this time in the General portion of each band about 50 KC up. Call "CQ Winter Carnival Award". The award is available to all Amateurs Worldwide who contact 3 Vernon area stations or one QSO with club station. The award is free but $1.00 or 2 IRC's to cover postage would be appreciated.

Broaden Your Viewing...



Complete Satellite T.V. System with 8 Ft. Parabolic Antenna

$995

Item No. SATEC3D1
Shipped motor freight collect

What the system will do:

Receives up to 60 channels of TV direct from satellites to your home receiver. Movies, sporting events, cultural and religious programs, other TV stations and much more.

What the system includes:

1. 8 ft. parabolic antenna made of reflective metal bonded with fiberglass. Weather resistant and virtually maintenance-free. In 4 sections for compact shipment.
2. Polar mount complete with azimuth and elevation adjustments for precise tracking. Available for earth or slab mounting.
3. Center feed LNA support with Polarmatic electronic feed and elbow wave guide. Enables polarity to be changed electronically without physically moving the LNA.
4. KLM Sky Eye V satellite receiver complete with downconverter. Features single conversion circuitry and SAW filter for outstanding reception. Single control for transponder selection, large signal strength meter and variable audio tuning from 5.5-7.5 MHz. Built-in RF modulator.
5. Amplica low noise amplifier. Rated at 120° K, uncooled. Takes the weak signals reflected from the dish antenna and raises them to a level usable by the downconverter. Uses GaAs FET transistors for maximum performance. Built-in lightning suppressor and weatherproof, cast aluminum housing.

Note: Small cables not included.
Fiberglass LNA cover sold separatly

Long's Electronics

VISA · American Express · master card

MAIL ORDERS: 2700 CRESTWOOD BLVD. B'HAM AL 35210 • SHOWROOM: 3131 4TH AVE. SO, B'HAM AL 35233

Clean up the radio/computer clutter.

For less than $250 you can make your investment in yourself pay off!

MICRO-OFFICE
WORK CENTER

Chances are you have spent a couple thousand dollars on setting up a computer system that gets a lot of your work done. But sometimes it gets to be work to work at it.

I know that when I have to move two program manuals and a pencil holder to boot up the disk drive, it is work. When there is an unlabeled floppy (that I am going to identify some day) on top of the monitor and the business checkbook is on top of the printer . . . and I will remember (I hope) before the next "report" comes through . . . that is work.

I found the annoyance of my own "computer clutter" was even worse than the extra work the disorder created. And that is when I started looking for some practical furniture for my computer set up. Since I had already spent a lot of money on the system itself, I was really dismayed when I found out how much it would cost to get a decent-looking desk or even a data table for my equipment. $400 . . . $500 . . . even more for a sleazy unit that looked like junk! In fact, it was junk! And it took a long time for me to find something that was really worth the money . . . and more.

A lot of my working day is spent with my computer, and I will bet a lot of your time is too. So I figure a "home" for my system—a housing that is good looking as well as efficient to work at—will pay off two ways:

1. Less work: an efficient and orderly layout will save me time and energy.
2. Personal satisfaction: good quality furnishings look better; they just plain feel better to work at too.

So imagine how good I felt to find the "Micro-Office" Work Center! These are fine pieces of computer system furniture that make my office-at-home as pleasant a place to work as it ought to be. And the biggest and best surprise is the low, low price for such good quality.

Here is what you get—all for only $249.50 plus shipping.

- Mar-resistant work surface. Your choice of oak or walnut grained. Work surface height is adjustable to your keyboard, your chair, your height.
- Two shelves plus work surface extender. Both shelves tilt to lock in position so that monitor faces you—in a position that does away with screen glare squinting and neck craning forever. Retainer bar keeps equipment from sliding off shelf. Snap-in bookends hold reference manuals and programs.
- Strong, sturdy and steady. All-steel welded frame construction is concealed by top-quality wood grain surfaces with finished trim. Adjustable floor levelers included. The work center is really a piece of fine furniture.
- There is no risk in buying from us either. We will make a full refund of purchase price plus shipping charges if you return the workcenter within 30 days for any reason whatsoever. In addition, the product is warrantied for any defects in materials or construction for a full year from date of purchase. This is a no-risk investment in your own productivity and work efficiency that will pay off for years to come—even if you do not yet have a microcomputer of your own.
- Take your choice for your own work center decor:

Order 48-inch unit in walnut, #2KPO-945, or in oak, #2KPO-947. Only $249.50 for each unit plus $20.00 shipping charge. On orders for two or more units at the same time, shipping charge applies to only the first unit ordered. Shipment made UPS, so we cannot ship to post office box. Illinois residents please add $15 per unit sales tax. Please allow 10 extra days for personal checks to clear. Sorry—at these special offer prices we cannot ship c.o.d. or bill direct.

CALL TOLL FREE TODAY WHILE SUPPLIES LAST: 1-800/323-8064.
In Illinois call 1-312/251-5699. Or mail check with order to:

Micro-Mart Distributors

Dept. HR • 1131 Central Street • Wilmette, IL 60091

Advertisers ✓ check-off

...for literature, in a hurry — we'll rush your name to the companies whose names you "**check-off**"

Place your check mark in the space between name and number. **Ex: Ham Radio ✓ 234**

Ace Comm. ___ 101
ACI ___ 102
AEA ___ 103
ARR ___ 104
Aluma ___ 105
Amateur Wholesale ___ 106
ARRL ___ 107
Analog Tech. ___ 108
Applied Inv. ___ 109
ATV Mag. ___ 110
Audio Forum ___ 111
Barker & Williamson ___ 112
Barry *
Bauman ___ 113
B.G. Micro ___ 114
BHCo ___ 115
Buckmaster ___ 116, 117
Butternut *
Caddell Coil ___ 118
Calvert Elec. ___ 119
Caywood ___ 120
Ceco ___ 121
CIA *
Chemtronics ___ 122
Comm. Concepts ___ 123
CES ___ 124
Comm. Spec. ___ 125
CPU ___ 126
Comp. Trader ___ 127
Cushcraft ___ 128
DCC Data ___ 129
Dayton Hamvention *
Digimax ___ 130
Doppler ___ 131
Electra ___ 132
Encomm ___ 133
Falcon ___ 134
Flesher ___ 135
GLB Elec. ___ 136
Globalman ___ 137
Hal-Tronix ___ 138
Ham Mastertapes ___ 139
HRB ___ 140
Ham Shack *
Hamtronics, N.Y. ___ 142
Handi-Tek ___ 143
Harvey ___ 144
Heath * ___ 145, 146, 147, 148
Henry Radio ___ 149
Hewlett-Packard ___ 307
Icom ___ 150, 308
Info. Un. ___ 151
Int. Union ___ 152
Jan Crystals ___ 153
J.C. Labs ___ 154
K & S ___ 155
KLM ___ 156
Kantronics ___ 157
Kenpro ___ 158
Kenwood *
Long's ___ 159
Lunar ___ 160
MFJ ___ 161
Macrotronics ___ 162, 304
Memphis Amateur Elec. ___ 163
Meshna ___ 164
Micro-Mart *
Mirage ___ 165
Missouri Radio ___ 166
Mosley ___ 167
Nampa ___ 168
Nemal ___ 169
Nuts & Volts ___ 170
Oak Hill Academy *
Orlando Hamcation *
Outprint ___ 171
P.C. Elec. ___ 172
Pro-Search ___ 173
Proham ___ 306
RF Products ___ 174
Callbook ___ 175
Ramsey ___ 176
Random Access ___ 177
Sartori ___ 305
Sherwood ___ 302
Shure Brothers ___ 178
Spectronics *
Spectrum Int. ___ 179
Spectrum West ___ 180
Spi-Ro Dist. ___ 181
TE Systems ___ 182
Telex *
Teltone ___ 183
Timekit ___ 184
Transleteronic ___ 185
Tri-Ex ___ 186
Triplett ___ 309
UNR-Rohn *
Vanguard ___ 187
Varian ___ 188
Vector Radio ___ 189, 303
Webster Comm. ___ 191
Westcom ___ 192
Western Elec. ___ 193
Westlink ___ 194
Yaesu ___ 195

*Please contact this advertiser directly.

Limit 15 inquiries per request.

February 1984

Please use before March 31, 1984

Tear off and mail to
HAM RADIO MAGAZINE — "check off"
Greenville, N. H. 03048-0498

NAME ....

CALL ....

STREET ....

CITY ....

STATE .... ZIP ....

Advertisers iNdex

ham radio
Reader Service

For literature or more information, circle the appropriate number on this card, affix postage and send to us. We'll hustle your name and address to the companies you're interested in.

101	113	125	137	149	161	173	185	197	209	221	233	245	257	269	281	293	305	317	329	341
102	114	126	138	150	162	174	186	198	210	222	234	246	258	270	282	294	306	318	330	342
103	115	127	139	151	163	175	187	199	211	223	235	247	259	271	283	295	307	319	331	343
104	116	128	140	152	164	176	188	200	212	224	236	248	260	272	284	296	308	320	332	344
105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285	297	309	321	333	345
106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286	298	310	322	334	346
107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311	323	335	347
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312	324	336	348
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313	325	337	349
110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315	327	339	
112	124	136	148	160	172	184	196	208	220	232	244	256	268	280	292	304	316	328	340	

Limit 15 inquiries per request.

NAME ______________________________ CALL ____________

ADDRESS ____

CITY ____________________ STATE ____________ ZIP ____________

Please use before March 31, 1984

February 1984

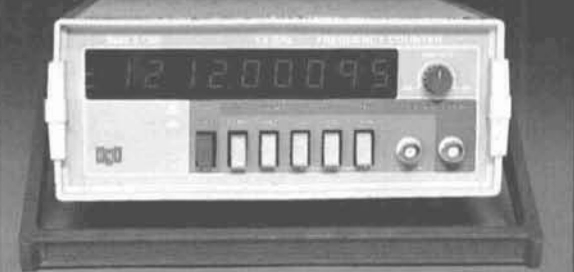
AFFIX POSTAGE
OR
POST OFFICE
WILL NOT
DELIVER

ham radio magazine

READER SERVICE CENTER
P.O. BOX 358
ARLINGTON, MA 02174

ATTN: Reader Service Dept.

ACCURACY DIGIMAX PERFORMANCE



10 MHz Oven Oscillator 9 X 8½ X 3¼
10 Hz to 1.2 GHz .1 PPM ACCURACY

5¼ X 5 X 1½

50 Hz to 512 MHz
1 PPM ACCURACY
TCXO

ALL MODELS HAVE 1 YEAR WARRANTY
Optional factory installed rechargeable battery pack available

VISA — master charge

FOR DEALER LOCATIONS
OR PHONE ORDERS
800-854-1566
5625 Kearny Villa Road
San Diego, CA 92123
California Call 619-569-6582
Telex #697120—DATAMAX-103

EXPORT AGENT: MAGNUS
3500 Devon Avenue
Chicago, IL 60659
312-679-6070
Telex #253503 MAGNUS CGO

DIGIMAX INSTRUMENTS CORP.

MODEL	PRICE	FREQUENCY RANGE	ACCURACY OVER TEMPERATURE	READ OUTS	SENSITIVITY TYP. 50 Hz-25 MHz	SENSITIVITY TYP. 25 MHz-450 MHz	POWER REQ.
D500	$149.95	50 Hz-512 MHz	1 PPM 17°-35°C TCXO TIME BASE	8	15 to 50 MV	20 to 50 MV to 450 MHz 50 to 100 MV to 1 GHz	8-15 VDC 300 MA
D510	$179.95	50 Hz-1.0 GHz					AC-12 REQ. FOR 110 VAC
D612	$259.95	50 Hz-1.2 GHz	0.1 PPM 20°-40°C PROPORTIONAL 10 MHz OVEN	9	15 to 50 MV	15 to 50 MV to 450 MHz 20 to 100 MV to 1 GHz	
D1200	$299.95	10 Hz-1.2 GHz			15 to 50 MV		8-15 VDC 500 MA

AC-12 AC-ADAPTER $8.95 T-1200 BNC-BASE 21" ANT. $8.95 BAC12 $34.95 BAC5 $29.95

✓ 130

APPLIED INVENTION

THE SOURCE FOR SOLID STATE / STATE OF THE ART

GaAs FETS by MITSUBISHI

2M — Ku Band. Very low noise and medium power 1-4

MGF 1100 Dual Gate GaAs FET 2.5dBNF @ 4GHz	$ 7.35
MGF 1202 (1402 chip in a 1200 package)	$ 9.70
MGF1404 GUARANTEED 0.65dBNF @ 4GHz	$66.60
MGF1402 0.4 dBNF @ 432, 1.1 dBNF @ 4GHz	$14.00
MGF1412 GUARANTEED 0.8, 0.9 or 1.0 dBNF @ 4GHz $21 —	$34.75
MGF1801 10GHz linear PO 150mW	$40.75

MITSUBISHI X BAND Hybrid Integrated Circuits with tuneable Dielectric Resonator (0.12MHz/°C) GaAs FET Oscillators

FO-1010X 10.4 GHz, 15mw out, UER100 Flange	$39.37
FO-1210Y 11.5 or 12.0 GHz UER120 Flange	$39.37
* **FO-UP11KF** Complete Heterodyne Rx 10.468 GHz LO	$36.22
Can be used for 12.5 GHz terrestrial and DBS	
* **FO-DP13KF** Doppler Module 10.525 GHz UER100 Flange	$43.05
* **X-Band** 15 dBG die cast horn antenna (UER100)	$17.85
* **GaAs FET Preamp** 1.7-2.1 GHz, 2.0-2.35 GHz, 2dBNF	$49.00

At THE SOURCE for RETICON Universal Audio Active Filters NEW

R5620 digitally programmed switched capacitor audio filter	$ 7.85
R5621 dual section resistor programmed SCF	$ 6.51
R5622 quad section resistor programmed SCF	$11.07
Out performs National MF 10' Application notes	$ 2.00

OPTOELECTRONICS from **MITSUBISHI** and **SIEMENS**
CW LASER DIODES, HIGH OUTPUT IRLEDS, PIN PHOTO DIODES CALL

MITSUBISHI BIPOLAR POWER TRANSISTORS FOR 900/1296
2SC2931, 2, 3, 4 (1.4 to 30 Watts PO) CALL

MRF 901 Substitute 2SC2876, Ft=7GHz, 2.2dBNF @ 1GHz	$ 1.50
NEC 64535 direct replacement Siemens BFQ 74	$ 9.66
LEADLESS DISK CAPS 100, 220, 470, 680, pF	10/$ 2.50
MICROWAVE CHIP CAPS Very low loss VITRAMON P7800 series G02(0.7-1.4 GHz) G04(1.3-2.6 GHz) G01(2.6-4.2GHz)	$ 1.25
VITRAMON VHF/UHF NPO chips 10, 100, 1000 pF	5/$ 2.50
A-B type FWSN 1000pF discoidal Feedthru	$ 0.75
STRIPLINE SHUTTLE TRIMMERS (VOLTRONICS) 0.1-2.5, 0.5-9.0pF	$ 3.34
HI-Q SEALED CERAMIC PISTON TRIMMERS (VOLTRONICS) 0.6-9.0pF	$ 3.58
SAPPHIRE TRIMMERS Johanson 0.4-2.5pF	$ 9.47
For WA2GFP preamp Sprague 0.6-4.5pF	$ 9.47
Thermo Electric Heat Pumps & Sub Miniature Cryogenic Refrigerators	CALL
3M GX250 glass/tfe board, Er=2.55 @ 10GHz 0.031	$0.31/sq. in
0.062	$0.52/sq. in
E.F. JOHNSON SMA's Sq flange female $3.50 Male cable	$ 2.88

PROMPT SERVICE SEND FOR CATALOG MINIMUM ORDER $5.00
VISA/MASTERCARD Accepted CASH prepay take 5% discount
S&H * ITEMS (UPS) $3.75 ALL OTHER ITEMS $2.50 (1st CLASS)
NY STATE RESIDENTS ADD 7% SALES TAX

R.D.2 ROUTE 21 HILLSDALE, NY 12529
518-325-3911 ✓ 109

UP YOUR ERP

For HT owners operating inside a vehicle and wanting increased T/R range, RF PRODUCTS has the low cost solution.

Remove your BNC antenna from the HT and mount on the RF PRODUCTS BNC magnet mount, install the magnet mount on the roof top and connect the BNC co-ax connector.

The magnet mount (part no. 199-445) has 10 feet of small (5/32") co-ax with BNC connector attached and is priced at $15.95 (including shipping by UPS to 48 states).

TO ORDER - send $15.95 money order or cashiers check only
Fla. residents add 5% tax, for air UPS add $1.50

The RF PRODUCTS Magnet Mounts are one of the few magnetic antenna mounts available that can be repaired should the co-ax cable be damaged. The co-ax cable connector includes a shrink tubing strain relief for long life at the connector/cable flex point (an RF PRODUCTS exclusive on all cable assemblies).

Eight other models available with three each choice of antenna connectors, co-ax types and transceiver connectors (BNC, 1-1/8-18, 5/16-24 & RG-122U, RG-58A/U, mini 8X & BNC, PL-259, type N).

✓ 174

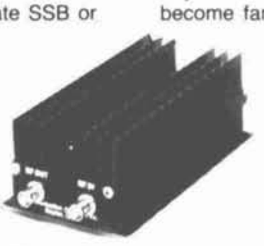
RF PRODUCTS

P.O. Box 33, Rockledge, FL 32955, U.S.A. (305) 631-0775

CALL LONG DISTANCE ON YOUR HANDHELD

The Model 335A will deliver 35 watts of power using the latest state-of-the-art circuitry. The amplifier will operate SSB or FM and is compatible with most handheld transceivers, including the TR2400, TR2500, IC-2AT, Yaesu, Santec, and Ten-Tec. Only 300 mw input will deliver 5 watts out; 3 watts in will deliver 35 watts out. Maximum input drive level is 5 watts.

Our products are backed by prompt factory service and technical assistance. To become familiar with our other fine products in the amateur radio market, call or write for our free product and small parts catalog.



Model 335 A
Kit $69.95
Wired & Tested $89.95

VISA

CCI Communication Concepts Inc.
2648 North Aragon Ave. • Dayton, Ohio 45420 • (513) 296-1411

master charge

✓ 123

YAESU FT-726R TRIBANDER

NEW GALAXIES OF PERFORMANCE ON VHF AND UHF

FULL DUPLEX!!

ATELLITES!! SCATTER!!

M!! EME!!

The New Yaesu FT-726R Tribander is the world's first multiband, multimode Amateur transceiver capable of full duplex operation. Whether you're interested in OSCAR, moonbounce, or terrestrial repeaters, you owe yourself a look at this one-of-a-kind technological wonder!

Multiband Capability

Factory equipped for 2 meter operation, the FT-726R is a three-band unit capable of operation on 10 meters, 6 meters, and/or two segments of the 70 cm band (430-440 or 440-450 MHz), using optional modules. The appropriate repeater shift is automatically programmed for each module. Other bands pending.

Advanced Microprocessor Control

Powered by an 8-bit Central Processing Unit, the ten-channel memory of the FT-726R stores both frequency and mode, with pushbutton transfer capability to either of two VFO registers. The synthesized VFO tunes in 20 Hz steps on SSB/CW, with selectable steps on FM. Scanning of the band or memories is provided.

Full Duplex Option

The optional SU-726 module provides a second, parallel IF strip, thereby allowing full duplex crossband satellite work. Either the transmit or receive frequency may be varied during transmission, for quick zero-beat on another station or for tracking Doppler shift.

High Performance Features

Borrowing heavily from Yaesu's HF transceiver experience, the FT-726R comes equipped with a speech processor, variable receiver bandwidth, IF shift, all-mode squelch, receiver audio tone control, and an IF noise blanker. When the optional XF-455MC CW filter is installed, CW Wide/Narrow selection is provided. Convenient rear panel connections allow quick interface to your station audio, linear amplifier, and control lines.

Leading the way into the space age of Ham communications, Yaesu's FT-726R is the first VHF/UHF base station built around modern-day requirements. If you're tired of piecing together converters, transmitter strips, and relays, ask your Authorized Yaesu Dealer for a demonstration of the exciting new FT-726R, the rig that will expand your DX horizons!

Price And Specifications Subject To Change Without Notice Or Obligation

✓ 195

YAESU
The radio.

483

YAESU ELECTRONICS CORPORATION 6851 Walthall Way, Paramount, CA 90723 • (213) 633-4007
YAESU CINCINNATI SERVICE CENTER 9070 Gold Park Drive, Hamilton, OH 45011 • (513) 874-3100

Scan the World.

SSB, CW, AM, FM, digital VFO's, 10 memories, band and memory scan, optional 118-174 MHz coverage...

R-2000

The R-2000 is an innovative all-mode SSB, CW, AM, FM receiver that covers 150 kHz—30 MHz, with an optional VC-10 VHF converter unit to provide coverage of the 118-174 MHz frequency range. New microprocessor controlled operating features and an "UP" conversion PLL circuit assure maximum flexibility and ease of operation to enhance the excitement of listening to stations around the world.

R-2000 FEATURES:

- **Covers 150 kHz—30 MHz in 30 bands.** Uses innovative UP-conversion digitally controlled PLL circuit. UP/DOWN band switches (1-MHz step). VFO's continuously tuneable across the band and from band to band.
- **Optional 118-174 MHz coverage.** Through use of innovative microprocessor technology, frequency, band, and mode data of stations in the 118-174 MHz range may be tuned, displayed (full frequency, ie., 146.000.0), stored in memory, recalled, and scanned, using the R-2000 front panel controls and frequency display, allowing maximum convenience and ease of operation.
  The optional VC-10 VHF converter unit may be easily installed on the rear panel of the R-2000.
- **All mode: USB, LSB, CW, AM, FM.** Provides expanded flexibility in receiving various signal types. Front panel mode selector keys, with LED indicators.
- **Digital VFO's for best stability.** 50-Hz step, switchable to 500-Hz or 5-kHz. F. LOCK switch provided.
- **Ten memories store frequency, band, and mode data.** Complete information on frequency, band, and mode is stored in memory, assuring maximum ease of operation. Each memory may be tuned as a VFO. Original memory frequency may be recalled. AUTO. M switch for automatic storage of current operating data, or, when off, selective storage of data using M. IN switch.
- **Lithium battery memory back-up. (Est. 5 yr. life.)**
- **Programmable memory scan.** Scans all memories, or may be programmed to scan specific memories. HOLD switch interrupts scanning. Frequency, band, and mode are automatically selected in accordance with the memory channel being scanned. The scanning time is approximately 2 seconds per channel.
- **Programmable band scan.** Scans automatically within the programmed bandwidth. Memory channels 9 and 0 establish upper and lower scan limits. HOLD switch interrupts scanning. Frequency may be adjusted, using the tuning control, during scan HOLD.
- **Fluorescent tube digital display (100-Hz resolution).** Built-in 7 digit fluorescent tube digital display indicates frequency or time, plus memory channel number. DIM switch provided. The display may be switched to indicate CLOCK-2, FREQUENCY, CLOCK-1, and timer ON or OFF by the front panel FUNCTION switch.
- **Dual 24-hour quartz clocks, with timer.**
- **Three built-in IF filters with NARROW/WIDE selector switch. (CW filter opt.)** 6-kHz wide or 2.7-kHz narrow on AM. 2.7-kHz automatic on SSB. 2.7-kHz wide on CW, or, with optional YG-455C filter installed, 500-Hz narrow. 15-kHz automatic on FM.
- **Squelch circuit, all mode, built-in, with BUSY indicator.**
- **Noise blanker built-in.**
- **Large front mounted speaker.**
- **Tone control.**
- **RF step attenuator. (0-10-20-30 dB.)** Four step attenuator, plus antenna fuse.
- **AGC switch. (Slow-Fast.)**
- **"S" meter, with SINPO "S" scale.**
- **100/120/220/240 VAC, or 13.8 VDC operation** (with opt. DCK-1 cable kit).

Other features.

- RECORD output jack.
- Audible "beeper" (through speaker).
- Carrying handle.
- Headphone jack.
- External speaker jack.

Optional accessories:

- VC-10 118-174 MHz converter.
- HS-4, HS-5, HS-6, HS-7 headphones.
- DCK-1 DC cable kit.
- YG-455C 500-Hz CW filter.
- HC-10 World digital quartz clock.
- AL-2 Surge Shunt

More information on the R-2000 is available from all authorized dealers of Trio-Kenwood Communications 1111 West Walnut Street Compton, California 90220.

KENWOOD

...pacesetter in amateur radio

Specifications and prices are subject to change without notice or obligation.